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ORIGINAL ARTICLES.

I.—Eminent Living Geologists.

William Carruthers, Hon. Phil. Dr. et A.M. (Upsala), F.R.S., F.L.S., F.G.S., F.R.M.S., F.R. Phys. Soc. et Bot. Soc. Edinb., Corr. Memb. Acad. N. Sci. Philad., etc.

(WITH A PORTRAIT,[1] PLATE X.)

IF we review the progress of any one of the natural sciences we shall find it is but the outcome of the genius and labours of many individual workers, who have devoted themselves for years to some particular branch of discovery or research. Taking palæobotany as an illustration, we may cite the name of William Carruthers as a striking example of an individual worker in that field, who, during more than a quarter of a century, specially devoted himself to the investigation and description of fossil plants, and has thus added largely to a knowledge of this section of the science of palæontology.

Born at Moffat, Dumfriesshire, on May 29, 1830, William Carruthers received his early education at Moffat Academy. Thence he proceeded, in 1845, to the University of Edinburgh. During two periods his regular course of studies was interrupted that he might hold tutorial posts, so that his University career was not completed until the spring of 1854. In the autumn of that year he was entered at New College, Edinburgh, with a view to study for the ministry of the Presbyterian Church. Here, under the teaching of Dr. John Fleming, the Professor of Natural Science, a man of conspicuous attainments as a naturalist, the inclination which Carruthers had already shown for science was strongly developed.

Acting under the advice and encouragement of Professor Fleming, who was then an old man, he devoted his energies to science with a view to becoming his colleague and successor. He accordingly studied in the University under Goodsir, Allman, and Balfour; but in 1858, before Carruthers' curriculum was finished, Professor Fleming died, and it was of course out of the question to appoint a student to the chair. It is interesting to note that forty-five years later Mr. Carruthers filled the chair for a year during a vacancy caused by the resignation of Professor Duns.

[1] This portrait, with some extracts from the text (by "S. W. C."), is reproduced from the Journal of the Royal Agricultural Society of England, vol. lxx, pp. 1–12, 1909, by kind permission of the Council.

His first position after leaving New College was that of Lecturer on Botany in the New Veterinary College, Edinburgh. A few months later he became Assistant to the Secretary of the Royal Society of Edinburgh, and in this capacity made the acquaintance of Dr. Robert Chambers, the publisher, which led later to his contributing the geological articles to the first edition of *Chambers' Encyclopædia*. William Carruthers' earliest scientific paper, recorded in the Royal Society's Catalogue, was a geological one on the Graptolites found in the rocks of his native county (Dumfriesshire), published in the Transactions of the Royal Physical Society of Edinburgh.

In 1859 he was offered, through Professor J. Hutton Balfour, the post of Assistant in the Department of Botany in the British Museum, and took up his duties there in August of that year, the staff of the Department at that time consisting of his chief (Mr. John Joseph Bennett) and himself. He thus definitely abandoned the Church as a profession, and devoted himself to science, but it was from no lack of sympathy with the Church, for throughout his life his great hobby has been Church history and theological literature.

In 1870 he was earnestly invited by Professor Asa Gray, the famous American botanist, to join him at Cambridge, Mass., with a view to his designating him as his successor. Mr. Carruthers was much drawn by this offer, but eventually decided not to give up his post in the Museum; indeed, in 1871 Mr. Bennett retired and Mr. Carruthers succeeded him as Keeper of Botany.

His first important studies in geology led him to undertake the careful investigation of the Graptolites of the Moffat Shales, and for some years he devoted his special attention to this group of organisms, in which Professor Lapworth, H. A. Nicholson, John Hopkinson, and others also laboured.

In the British Museum he had under his immediate charge a large and valuable series of fossil plants, mostly showing structure, being a part of the collection of the celebrated botanist Robert Brown, the first Keeper of the Botanical Department (1827), who died in London, June 10, 1858, the year before Carruthers entered the Museum. He also made good use of the fossil plants preserved in the Geological Department, to which he had free access. His first important paper related to the fructification of *Lepidodendron*, material for which he found in the Robert Brown Collection and in the Geological Department. He not only described the fossil spore-bearing cones of (*a*) *Lepidostrobus Brownii* and *L. ornatus*, and of (*b*) *Flemingites gracilis*, but he further showed that the presence of these shed spores was characteristic of, and made up entirely, a number of beds of coal as the 'splint-coal', the Fordel-coal, the 'parrot', the 'cherry', and cannel coals, as first noticed by Witham, Fleming, Prestwich, Morris, and other early observers, and he was thus able to connect them with the spore-bearing cones of *Lepidodendron*, which he figured in detail and accurately described (Geol. Mag., 1865, pp. 433–40, Pl. XII).

Apart from the purely systematic and descriptive papers on palæobotanical subjects, of which a list is given at the end of this notice, one of the most valuable and instructive contributions to fossil

botany, from a student's and intellectual observer's point of view, was given by Mr. Carruthers in his historic lecture at the Royal Institution on Friday, April 16, 1869, on "The Cryptogamic Forests of the Coal Period", printed in this Magazine (GEOL. MAG., Vol. VI, pp. 289–300, 1869).

In it we have a clear and concise description of the vegetation of certainly the most wonderful period of plant-development known in the past ages of our earth, and the author points to the remarkable fact that the vast stores of carbonized plant-remains on which human progress, arts, manufactures, and commerce now depend, were derived from the accumulated growth, not of the highly specialized forms of plant-life which chiefly characterize our present flora, but from humble vascular Cryptogams, Ferns, Equisetaceæ, Lycopodiaceæ, and 'Pill-worts' (Marsiliaceæ), many of which (as the 'Club-mosses' and 'Horse-tails') attained to giant growths and formed veritable forests, which for ages incalculable must have flourished (homotaxially, if not synchronously) over nearly the whole earth.

This chapter of the past, written by such an expert as Mr. Carruthers, needs but to be repeated by similar Evangels for every other geological stage to make our earth's past history a veritable fairy tale of delightful literature for all.

From 1871 to 1880—when the removal of the Natural History Collections to Cromwell Road took place—the restricted space occupied by the exhibited Botanical Series and the Herbarium itself, at Bloomsbury, precluded the possibility of any great expansion or proper display, and the very life of the Department itself was threatened also by a powerful attempt to capture the Museum Collection and transfer it to Kew. But Mr. Carruthers' evidence before the Royal Commission on Scientific Instruction made so clear a case for the existence of the botanical collections as a part of the great Natural History Collections, in our National Museum in London, as to fully justify and firmly secure its continuance.

When the removal to South Kensington was effected in 1880, adequate space was allotted to the Botanical Department, and the work of re-arranging both the public exhibits and the collections for the use of students owed much to Mr. Carruthers' talent for organization.

In labelling and illustrating the specimens in the public collections, moreover, he was one of the pioneers of the system of giving adequate explanations on the labels, thus making the collections far more interesting and instructive to the public.

The removal to South Kensington necessitated the creation of a Departmental Library, for which a special grant was made. This task occupied Mr. Carruthers for some years, resulting in the formation of what has now become the finest botanical library in the world.

In 1870 the Linnean Society published Mr. Carruthers' very important monograph "On the Fossil Cycadean Stems from the Secondary Rocks of Britain" (Trans. Linn. Soc., vol. xxvi, pp. 675–708, with ten plates, 1870, 4to). In this work one realizes the advantage of the author having an accurate knowledge of recent plants, both structural and physiological, thus giving to his published opinions on

the plant-remains found embedded in the various strata a far greater value and scientific importance.

In 1871 William Carruthers obtained the honour of election to the Royal Society, on the Council of which he served (1877–9). In 1871 he was appointed Consulting Botanist to the Royal Agricultural Society of England, a post which he held with distinction for thirty-nine years.

In 1884 he attended the meeting of the British Association in Montreal and took a long trip in America (in company with the late Mr. Charles de Laune Faunce de Laune and Mr. F. S. W. Cornwallis), in the course of which he secured interesting specimens for his Department, and got into closer touch with museums and herbaria on the American continent. He and his fellow-travellers also gathered much valuable experience in agricultural botany on this expedition.

In 1886 he was President of the Biological Section of the British Association, at its Birmingham meeting, and there delivered an address on the persistence of specific characters in plants, which presented so difficult a problem to the supporters of the Darwinian theory that it remains unanswered to this day.

From 1886 to 1890 Mr. Carruthers was chosen to be President of the Linnean Society, in which period its centenary celebrations fell; and for organizing and carrying through these important commemorations he received the Society's thanks. The Linnean Medal was then founded, and he had the pleasure of presenting the first medals to Sir Richard Owen and Sir Joseph Hooker. In 1907 Mr. Carruthers was sent by this Society to Sweden as its representative at the bicentenary commemorations of the birth of Linné, and at that time the ancient University of Upsala conferred on him the honorary degrees of M.A. and Ph.D. He had also been elected President of the Geologists' Association 1875–7, and of the Royal Microscopical Society 1900–1. He retired from the Keepership of Botany in the British Museum (Nat. Hist.), under the age clause, in 1895, when the scientific staff consisted of the keeper and five assistants.

The number of papers published by Mr. Carruthers upon recent botanical subjects (especially in connexion with Economic Botany for the Royal Agricultural Society) amounts to considerably over 100. Those enumerated in the annexed list relate to palæontological and geological subjects only.

His care in attention to detail, without losing sight of salient points, his power of lucid exposition of a subject, and his willingness to satisfy any genuine desire for knowledge have made him a most useful officer both to the British Museum and the Royal Agricultural Society of England.

Speaking of William Carruthers' personal character the writer has ever found him, during forty years association, a most consistent and true friend and a staunch and faithful colleague. Like many of his countrymen from across the Tweed he was a good fighter, and when he had made up his mind that his cause was a just one he was very tenacious in maintaining his ground. Had he lived in the old days he would certainly have been a good fighting Covenanter. His list of honours is a long one, but are they not all duly recorded in the Year Book of the Royal Society for 1912, p. 8?

In 1865 he married Jane Couch, eldest daughter of William L. Moffatt, Architect, Edinburgh, and has two sons and a daughter. His second son, John Bennett, followed his father's footsteps, and took up Economic Botany. After acting as assistant in his father's laboratory and giving special attention to the diseases of plants, he went to Ceylon at the request of the planters to investigate a malady destroying the Cacao trees. Thereafter he entered the Colonial Service and did excellent pioneer work in Ceylon, the Federated Malay States, and Trinidad, where he died in 1910 at the early age of 41. The elder son, Samuel William, who has an honours M.D. of Edinburgh, is in practice at Norwood, and his daughter has her home in the same suburb.

He is now enjoying with his family near him, at Central Hill, Norwood, the repose of a long, useful, and honourable life.

LIST OF CONTRIBUTIONS TO PALÆONTOLOGY, ETC., BY DR. WILLIAM CARRUTHERS, F.R.S.

1858. "Dumfriesshire Graptolites, with descriptions of three new species": Proc. Phys. Soc. Edinburgh, vol. i, pp. 466–70; [republished in] Ann. Mag. Nat. Hist., vol. iii, pp. 23–6, 1859.

1862. "The Geology of Moffat": Proc. Phys. Soc. Edinburgh, vol. ii, pp. 383–90; Edinburgh New Phil. Journ., vol. xvi, pp. 33–40.

"On a section at Junction Road, Leith": Quart. Journ. Geol. Soc., vol. xviii, pp. 450–3.

1865. "On an undescribed Cone from the Carboniferous beds of Airdree, Lanarkshire: *Flemingites gracilis*": GEOL. MAG., Vol. II, pp. 433–40, Pl. XII.

"On *Caulopteris punctata*, Goepp., a tree-fern from the Upper Greensand of Shaftesbury in Dorsetshire": ibid., pp. 484–7.

1866. "On the Vegetation of the Coal Period": ibid., Vol. III, pp. 229–30.

"On Araucarian Cones from the Secondary beds of Britain": ibid., pp. 249–52.

"On some fossil Coniferous fruits": ibid., pp. 534–46.

"On the structure and affinities of *Lepidodendron* and *Calamites*": Trans. Bot. Soc. Edinburgh, vol. viii, pp. 495–507; Journ. Bot., vol. iv, pp. 337–48.

1867. "On Gymnospermatous fruits from the Secondary rocks of Britain": Journ. Bot., vol. v, pp. 1–21.

"On Calamiteæ and fossil Equisetaceæ": ibid., p. 304.

"On the structure of the fruit of *Calamites*": ibid., pp. 349–56.

"Note on the systematic position of Graptolites and on their supposed ovaria-vesicles": GEOL. MAG., Vol. IV, pp. 70–2, 187, 336.

"On some Cycadean fruits from the Secondary rocks of Britain": ibid., pp. 101–6.

"On an Aroideous fruit from the Stonesfield Slate": ibid., pp. 146–7.

"On *Cycadoidea Yatesii*, a fossil Cycadean stem from the Potton Sands, Bedfordshire": ibid., pp. 199–201.

Appendix D, on Graptolites, in Sir R. I. Murchison, *Siluria* [London].

"Graptolites, their structure and systematic position": *Intellectual Observer*, vol. xi, pp. 283–92, 365–74.

"On British Fossil Cycadeæ": Journ. Bot., vol. v, pp. 302–4; Rep. Brit. Assoc. Adv. Sci. (Dundee, 1867) [1868], p. 80.

"Enumeration of British Graptolites": ibid., p. 57.

"On the fruit of a *Pandanus* from the Great Oolite": Journ. Bot., vol. v, p. 304. [Abstract of paper read before Dundee Meeting, Brit. Assoc.]

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"On the fruit of a *Pandanus* from the Great Oolite": Journ. Bot., vol. v, p. 304. [Abstract of paper read before Dundee Meeting, Brit. Assoc.]

1868. "A Revision of the British Graptolites, with descriptions of the new species and notes on their affinities": GEOL. MAG., Vol. V, pp. 64–74, 125–33.
"British Fossil Pandaneæ": ibid., pp. 153–6.
"Classification of Graptolites": ibid., pp. 199–200 [letter to Editor].

1869. "On some undescribed Coniferous fruits from the Secondary rocks of Britain": ibid, Vol. VI, pp. 1–7.
"On *Beania*, a new genus of Cycadean fruit, from the Yorkshire Oolites": ibid., pp. 97–9.
"On the plant remains from the Brazilian coal beds, with remarks on the genus *Flemingites*": ibid., pp. 151–6.
"On the plant remains found in the Cretaceous and Tertiary strata of N. America": Journ. Bot., vol. vii, 82–5.
"On the genus *Knorria*, Sternberg": ibid., pp. 153–5.
"On the structure and affinities of *Sigillaria* and allied genera": Quart. Journ. Geol. Soc., vol. xxv, pp. 248–54, pl. x; Phil. Mag., vol. xxxviii, p. 402.
"Age of the Rocks of Alaska Territory": GEOL. MAG., Vol. VI, p. 239 [letter to Editor].
"The Cryptogamic forests of the Coal Period": ibid., pp. 289–300; Proc. Royal Institution, vol. v, pp. 511–22.

1869–70. "On the structure of the stems of the Arborescent Lycopodiaceæ of the Coal Measures": Monthly Micros. Journ., vol. ii (1869), pp. 177–81, 225–7; vol. iii (1870), pp. 144–54.
"On Reptilian Eggs from Secondary Strata"; "On Slickensides": Notice of papers read at Exeter Meeting (1869), Brit. Assoc. Adv. Sci., Rep. p. 86 [1870].

1870. "Review of the contributions to Fossil Botany published in Britain in 1869": GEOL. MAG., Vol. VII, pp. 181–4.
"On the Petrified Forests near Cairo": ibid., pp. 306–10, Pl. XIV.
"On the structure of a fern stem from the Lower Eocene of Herne Bay, and its allies, recent and fossil": Q.J.G.S., vol. xxvi, pp. 349–53, pls. xxiv, xxv; Phil. Mag., vol. xl, pp. 225, 226.
"On the nature of the scars in the stems of *Ulodendron*, *Bothrodendron*, and *Megaphyllum*, with a synopsis of the species found in Britain": Monthly Micros. Journ., vol. iii, pp. 144 et seq.
"On fossil Cycadean stems from the Secondary rocks of Britain": Trans. Linn. Soc., vol. xxvi, pp. 675–708, with ten plates, 4to.
"On the history and affinities of the British Coniferæ": Rep. Brit. Assoc. Adv. Sci. (Liverpool, 1870) [1871], p. 71.
"On the Sporangia of Ferns from the Coal-measures": ibid.
"Remarks on the fossils from the railway section at Hoyton": ibid., pp. 71–2.
"Note on an *Antholithes* discovered by C. W. Peach": ibid., p. 72. [Abstract.]

1871. "On the vegetable contents of masses of limestone occurring in Trappean rocks in Fifeshire, and the conditions under which they are preserved": Rep. Brit. Assoc. Adv. Sci. (1871), pp. 94–5.
"Review and Synopsis of the contributions to Fossil Botany published in Britain in 1870": GEOL. MAG., Vol. VIII, pp. 218–20.
"On two undescribed Coniferous fruits from the Secondary rocks of Britain: *Pinites hexagonus*, *Sequoiites ovalis*": ibid., pp. 540–4.
"On some vegetable structures recently discovered in the Lower Coal-beds at Halifax, 1870": Rep. Croydon Micros. Club, vol. i, pp. 26–7.
"On some supposed Vegetable Fossils": Q.J.G.S., vol. xxvii, pp. 443–8, pl. xix.

1872. "On the leaf-bearing species of *Lepidodendron*": Monthly Micros. Journ., vol. vii, pp. 50–4.

"On the history, histological structure, and affinities of *Nematophycus Logani*, Carr. (*Prototaxites Logani*, Dawson), an alga of Devonian age": ibid., vol. viii, pp. 160–72, pls. xxxi–ii.

"On *Traquairia*, a Radiolarian Rhizopod from the Coal-measures": Rep. Brit. Assoc. Adv. Sci., 1872, p. 126; Quart. Journ. Micros. Sci., vol. xii, pp. 397–8.

"Note on some supposed fragments of a *Eurypterus*": in Dr. H. Woodward's *British Fossil Crustacea—Merostomata* (Mon. Pal. Soc.), pp. 168–71.

"Notes on some Fossil Plants from Queensland, Australia": Q.J.G.S., vol. xxviii, pp. 350–60. Appendix II in R. Daintree, *Notes on the Geology of the Colony of Queensland*.

"Notes on some Fossil Plants": GEOL. MAG., Vol. IX, pp. 49–59, Pl. II.

"Review of the contributions to Fossil Botany published in Britain in 1871": ibid., pp. 369–73.

1872–3. "On the Tree Ferns of the Coal Measures, and their affinities with existing forms": Rep. Brit. Assoc. Adv. Sci., 1872 [1873], pp. 98–9; GEOL. MAG., Vol. IX, pp. 465–7; Journ. Bot., vol. vii, pp. 279–81, 1872; Q.J.G.S., vol. xxix, pp. 380–1.

1873. "On *Halonia* of Lindley & Hutton and *Cyclocladia* of Goldenburg": GEOL. MAG., Vol. X, pp. 146–52, Pl. VII.

"Review of the contributions to Fossil Botany published in Britain in 1872": ibid., pp. 461–5.

"*Nematophycus* or *Prototaxites*?": Monthly Micros. Journ., vol. x, pp. 208–10.

"On the Tree Ferns of the Coal Measures, and their relations to other living and fossil forms": Q.J.G.S., vol. xxix, p. 380. [Abstract.]

"On some Lycopodiaceous plants from the Old Red Sandstone of the North of Scotland": Journ. Bot., vol. ii, pp. 321–7.

1876. "On the Flora of the London Clay of Sheppey": Proc. Geol. Assoc., vol. iv, pp. 318–19.

"Note on the Flora of the Gault, with description of a new pine cone, *Pinites Pricei*": ibid., pp. 278–81.

1876–8. ["Fossil Plants"] Presidential Address to Geologists' Association, November 1875: ibid., vol. v, 1876–8, pp. 1–16.

["Evolution of Plant Life"] Presidential Address to the Geologists' Association, November, 1876: ibid., pp. 17–35; GEOL. MAG., 1876, pp. 560–5.

1877. "Description of a new species of *Araucarites* from the Coralline Oolite of Malton" [in Blake & Hudlestone]: Q.J.G.S., vol. xxxiii, p. 402.

1878. "Descriptions of Tertiary Plant-remains from Bracklesham and Worthing, Sussex"; "The Plant-remains of the Upper and Lower Cretaceous (Neocomian) Formations in England": in F. Dixon, *The Geology of Sussex*, new [second] edition, 1878.

1879. "Note on Mr. Lee's specimens of fossil wood from Griqualand": GEOL. MAG., Vol. VI, p. 286 [letter to Editor].

1880. "On a collection of Fossils from the Bowen River Coal-field, etc.": [in Etheridge] Proc. R. Phys. Soc. Edinburgh, vol. v, p. 325.

1882. "Contributions to the Palæobotany of Sweden": GEOL. MAG., Vol. IX, pp. 22–4.

1883. "On the foliage of *Sigillaria Serlii*, Brongn.": ibid., Vol. X, pp. 49–50.

1884. "Coal, and the Plants which form it": Ann. Rep. Dulwich Coll. Sci. Soc., 1883–4, pp. 39–41.

1885. "Notes on Fossil Roots in the Sarsen Stones in Wiltshire": GEOL. MAG., Ser. III, Vol. II, pp. 361–2.

II.—Sedgwick Museum Notes.

By F. R. Cowper Reed, M.A., F.G.S.

(PLATE XI.)

Dionide atra, Salter. (Pl. XI, Figs. 1–6.)

In 1866 Salter[1] established this species on the basis of two somewhat distorted pygidia, but the head-shield and thorax have remained undescribed and apparently unknown. The discovery therefore by Mr. V. M. Turnbull of some complete though somewhat imperfectly preserved individuals in the Arenig Beds near Haverfordwest is of not a little interest; and with the aid of several detached head-shields, in addition to those belonging to individuals with typical pygidia, we are able to give a fairly complete description of the species, which, owing to its relations to other genera, is particularly worthy of note.

Description. Head-shield semicircular or semi-elliptical, gently convex, with genal angles produced broadly backward and pointed. Border narrow, smooth, widest in front, narrowing posteriorly on each side, separated from rest of head-shield by narrow marginal furrow in which lies a single row of equidistant and equal elongated pits.

Cheeks gently convex, divided into (1) an outer circumferential region, and (2) an inner triangular region on each side of glabella, and connected in front of it by a narrow band. Circumferential region produced back into genal prolongations; marked off from inner region by possessing a slight independent convexity and by a different ornamentation; internally defined by three concave curves, two lateral and one median, meeting on each side in obtuse angles a little behind anterior end of glabella; median part of circumferential region of uniform width; lateral parts widest at obtuse angles of junction, and sharply bounded behind by fine raised vascular trunk running backwards towards genal angles. Surface of circumferential region marked by radiating sinuous branching and anastomosing fine thread-like lines interspersed with minute pits, the radial arrangement of the lines becoming less apparent towards genal angles.

Inner regions of cheeks with straight posterior edge furnished with narrow pleuro-occipital segment marked off by strong furrow, each inner region thus forming a quarter of a circle, and connected in front of the obtuse angles of circumferential region by narrow pre-glabellar band of uniform width surrounding anterior end of glabella. Surface of inner region of cheeks crossed diagonally by gently curved strong line ('cheek-line') starting from middle of side of glabella and running outwards and backwards to meet inner edge of circumferential region a little in front of inner angle of genal prolongations, with traces of small 'ocular' tubercle on it at about the middle of the cheek; very minute punctæ and extremely delicate striæ present over whole surface.

Glabella oval, slightly angulated at front end, produced behind into short blunt median spine, moderately convex, about two-thirds the length of the head-shield; small elongated median tubercle present,

[1] Salter, Mem. Geol. Surv., vol. iii, p. 321, pl. xi *a*, figs. 9, 9*a*.

and traces of a pair of small depressed triangular basal lobes at sides of median spinose prolongation. Surface of glabella ornamented like inner region of cheeks.

Axial furrows united in front of glabella, with small pit at front end on each side.

Thorax imperfectly known; axis as wide as glabella, cylindrical; pleuræ horizontally extended, straight, of uniform width, with fine diagonal furrow and obliquely truncate ends (?).

Pygidium parabolic, flattened, nearly as long as wide; axis conical, elongated, about one-fifth the width of pygidium in front, tapering to blunt end not quite reaching posterior margin of pygidium, completely annulated to tip by 20–24 well-defined rings, of which the anterior ones have the interannular furrows trilobate, being arched forward in the middle and at the sides. Lateral lobes horizontal, nearly flat, composed of 15–17 well-marked straight radiating pleuræ, widening outwards but ending a short distance inside the margin (the last 5–6 pleuræ arch slightly backwards and become subparallel); each pleura marked by fine submedian slightly diagonal furrow reaching nearly to extremity. No border present.

Surface of thorax and pygidium very minutely punctate.

Dimensions.	mm.
Length of head-shield	about 7·5
Width of head-shield	,, 15·0
Length of pygidium	,, 6·5
Width of pygidium	,, 7·5

Horizon and Localities. Upper Arenig: Ty Obry, Portmadoc (Salter's types); Long Plantation Cutting, near Scolton, Haverfordwest (Turnbull's specimens).

Remarks. The pygidium of this trilobite as represented by Mr. Turnbull's specimens is certainly identical with that described and figured by Salter[1] as *Dionide atra* from Ty Obry, Portmadoc; but the two type-specimens are distorted, one being laterally compressed and therefore unduly elongate in appearance (Salter, op. cit., fig. 9), and the other being unnaturally broadened out transversely (Salter, op. cit., fig. 9*a*). In the latter specimen the inner surface is exposed and a narrow doublure of uniform width is therefore visible. In the elongated specimen (here figured) the axis shows 20–22 rings and over 20 pleuræ are present on the lateral lobes, while in the other about 16–20 pleuræ can be counted. Salter seems to have been incorrect in stating that the pleuræ are interlined (=furrowed) for only their first half and that the furrows bend back abruptly, but the mistake arose from the poor preservation of the types.

The head-shield and thorax of this species have been hitherto unknown, and it is satisfactory to find them now in attachment to the pygidium. The isolated head-shields are better preserved than the more complete specimens, though those belonging to the two individuals possessing much of the rest of the body show the characters with quite sufficient distinctness. The structural characters of this

[1] Salter, Mem. Geol. Surv., vol. iii, p. 321, pl. xi*a*, figs. 9, 9*a*.

species are interesting, for the division of the cheeks into two distinct regions recalls the features of the 'cheek-roll' and 'cheek-lobes' of many species of *Harpes*, as carefully described by Bather[1] in the case of *H. bucco*. The marginal row of pits suggests a comparison with that found at the base of the cheek-roll and inner margin of the 'brim' in many species of that genus, and the 'cheek-line' with that in *H. vittatus*, Barr. The distinctive ornamentation of the outer and inner portions of the cheeks is also commonly met with in *Harpes* and *Harpides*, but not in *Dionide*. With regard to *Erinnys*, as defined by Grönwall,[2] we may note the similarity of the main vascular trunk running backwards and outwards with radial branches arising from it, especially on the anterior side, and in *E. breviceps* (Angelin) there is a somewhat similar row of marginal pits.

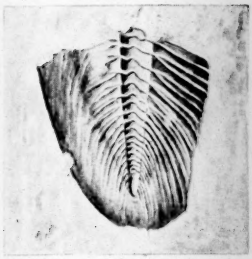
But the reference to the genus *Dionide* seems beyond dispute on the strength of the large size, many annulations, and other characters of the pygidium which may be compared[3] with that of *D. lapworthi* (Eth. & Nich.), *D. formosa*, Barr., and *D. euglypta*, Angelin. The many points of affinity possessed by the head-shield with other genera indicate the intimate relations of *Dionide* with *Harpes*, *Harpides*, and *Erinnys*.

In 1875 Hicks[4] described and figured a trilobite from the Upper Arenig of the St. David's area as *Trinucleus Ramsayi*. The material was very poor and fragmentary, but a comparison of the types with the head-shields of *D. atra* leads me to believe that they are identical, and if so Hicks' name must be dropped. The imperfect head-shields on which Hicks based his species show the single marginal row of pits, the radially ornamented circumferential region of the cheeks, the pre-glabellar band of the inner region, the 'cheek-line', the main vascular trunk, and the general shape and contour of *D. atra*, so far as their fragmentary condition allows us to determine. The only difference is the rather coarser ornament of the 'cheek-lobes', though it is likewise very much finer and quite different from that of the 'fringe' (=circumferential region). The greater coarseness seems probably due to the state and method of preservation of the specimens and to the larger size of the individuals which Hicks figured. No other feature of importance is present by which we can separate them, and the St. David's *Trinucleus Ramsayi* must undoubtedly be referred to the genus *Dionide*, and almost certainly to Salter's species. Fearnsides[5] has mentioned a *Dionide* "closely similar to the *D. atra* of Ty Obry" as occurring in the Olchfa or *bifidus* Shales of the Arenig fawr district.

EXPLANATION OF PLATE XI.

FIG. 1. *Dionide atra*, Salter. Pygidium, elongated and distorted. Ty Obry, Portmadoc. (Probably the specimen figured by Salter, Mem. Geol. Surv., iii, pl. xi*a*, fig. 9.) × 2.

[1] Bather, "*Harpes bucco*": Rivista Ital. Paleont., xv, pp. 116–20, 1910.
[2] Grönwall, "Bornholms Paradoxideslag": (Danmarks geol. Undersog., ii, Nr. 13), 1902, pp. 94–98.
[3] Reed, Mon. Girvan Trilob. (Palæont. Soc.), 1903, pt. i, p. 26.
[4] Hicks, Quart. Journ. Geol. Soc., vol. xxxi, p. 183, pl. x, figs. 1, 2, 1875.
[5] Fearnsides, ibid., vol. lxi, p. 623, 1905.



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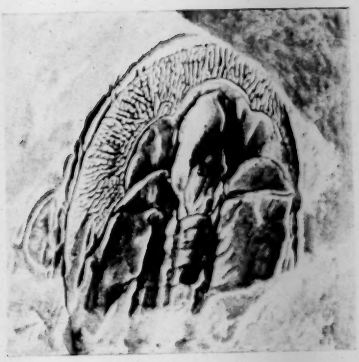

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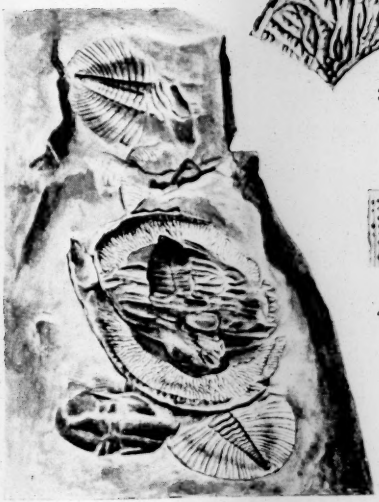
2a

3a

4



2

4b

4a

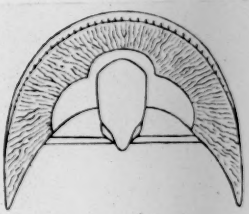


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FIG. 1. *Dianide atra*, Salter, 1866. Upper Arenig: Portmadoc.
FIGS. 2–6. Ditto. Upper Arenig: near Haverfordwest.

FIG. 2. *Dionide atra*, Salter. Group of portions of two individuals, broken and displaced, showing external impression of parts of head-shields, fragments of thorax, and the two pygidia. Upper Arenig Series: Long Plantation Cutting, near Scolton, Haverfordwest. × 2.
,, 2*a*. Ditto. One of the pygidia. × 3.
,, 3. Ditto. Head-shield of another individual with part of thorax attached. Same horizon and locality. × 4.
,, 3*a*. Ditto. Portion of circumferential region of same specimen. × 8.
,, 4. Ditto. Head-shield, showing border. Same horizon and locality. × 3.
,, 4*a*. Ditto. Impression of same specimen. × 3.
,, 4*b*. Ditto. Portion of cheek of same specimen showing ornamentation. × 8.
,, 5. Ditto. Head-shield, transversely distorted. Same horizon and locality. × 3.
,, 6. Ditto. Diagrammatic restoration of head-shield.

III.—On the Geology of Venezuela.

By Leonard V. Dalton, B.Sc. (Lond.), F.G.S.

I. Introductory.

ALTHOUGH the Republic of Venezuela adjoins two British colonies, only some three or four papers have been published in English journals dealing with the geology of the country. These, moreover, are concerned with local observations, and no attempt at correlation has been made. A considerable mass of material is available in Continental publications, and the author, during a series of journeys through Northern Venezuela in 1910, was able to collect sufficient data to form a fairly clear idea of the succession of deposits, and to roughly correlate the views of different writers. While more compilatory than original, the following paper is offered as a basis for further study of the geology of an area so closely connected with the colonies of British Guiana and Trinidad, and the short bibliography includes all those papers bearing directly on the subject which are known to the author.

From a geological point of view there are two distinct areas in Venezuela between which there are few points of resemblance in general character, namely, the area south of the Orinoco, commonly known as Guayana, or the Guayana Highlands, and Northern Venezuela. In the first we have an ancient, extremely stable, land-surface, which has undergone few changes since the dawn of geological history, and none at all in recent periods; north of it lies an area which has been the scene of great geological changes down to quite recent times, and where numerous earthquakes still testify to lack of equilibrium in the region. Since the rocks of the south are all of greater antiquity than any of those constituting the region north of the Orinoco, the whole series of deposits will be briefly described in order, beginning with the most ancient, while the various igneous rocks will be mentioned along with their associated sedimentaries.

II. Succession of Deposits.

Wherever travellers have collected data in the Guayana region they report a foundation of granite, gneiss, schist, or similar rock, and where, as in the gold-bearing region of Yuruari, these

observations can be linked on with the fuller and more scientific records of British Guiana, there is evidence that the lowest rocks over the whole area form a complex of ancient igneous or highly metamorphosed sedimentary deposits, similar in petrological character, both macro- and microscopically, to the oldest rocks of other parts of the globe, and notably to the Lewisian complex of the Scottish Highlands. It seems justifiable therefore to consider them, provisionally at least, as of Archæan or pre-Cambrian age, and as representing some of the most ancient parts of the solid crust of the globe.

These Archæan rocks occur, as has been stated, over the whole Guayana region, constituting hills in some parts, but generally forming the more or less level platform from which the more notable elevations rise. South of Ciudad Bolivar, where they have been studied in most detail, they include gneisses, hornblende schists, and granites, all containing evidence of great antiquity in geological time. Traversing these are two series of dykes, or intrusions in other form of igneous rocks, one ancient, the other, as will be seen, of later date. The older series consists of acidic material, mainly quartz-porphyrites and felsites, which, with the surrounding rocks, have undergone considerable dynamic or regional metamorphism. Traversing these, in belts which have a general N.W.–S.E. strike, are dykes and sills of basic material, including basalts and dolerites; along these intrusions, particularly near their intersection with the older series, the majority of the mineral veins are found.

The basal complex everywhere consists of the original gneisses, etc., and the acidic intrusives, while, resting upon these at very many points in Guayana, are red and white sandstones and coarse conglomerates, with a few bands of red shale, in a series about 2,000 feet thick. All the materials of this series of beds appear to have been derived directly from the gneisses; the strata are practically horizontal and have suffered little fracturing, save where they are traversed by the basic intrusives already referred to, which are thus shown to be of much later date than the acidic rocks. From analogy with Brazil it may be inferred that the basalts, etc., are of Secondary age; in the sandstone groups the sills frequently expand into laccoliths, and in British Guiana it is found that the protection afforded to the sedimentaries under the intrusions of igneous rock has caused them to remain after the denudation of the surrounding areas, forming peculiar flat-topped mountains with vertical cliffs on every side. Whether all the peculiar elevations of this type, so characteristic of Guayana, are due to igneous intrusions is a point upon which we may one day be enlightened. Certain it is that the Sierra Pacaraima, and the vertical-sided outliers north of it, are composed, for the greater part, of these horizontal sandstones. Mount Roraima gives the best known section of these rocks, and *Roraima Series* would seem a fitting name for them.

No fossils are known to occur in the rocks of the Roraima Series, but since they are traversed by Mesozoic intrusives they must be assumed to belong at latest to the early part of that period; while from their constitutional resemblance to the Torridonian Sandstone

of the Scottish Highlands, and exactly similar relation to the Archæan complex below, it may be reasoned that they should be considered as equivalent in age, and therefore forming, with the Guayana complex, the most ancient rocks in Venezuela.

North of the Orinoco we have in the Caribbean Hills and elsewhere a series of gneissose and schistose rocks, named by Wall in 1860 the *Caribbean Series*. The group includes silvery mica-schists (not infrequently mistaken for gold or silver ores), graphitic schists and gneisses with banding of all degrees of fineness, whilst, in addition, crystalline limestones occur in Eastern Venezuela. The thickness of the group is not known with any certainty, but Mr. E. H. C. Craig estimated it at less than 2,000 feet in Trinidad, though, owing to crushing and complicated folding, the apparent thickness is much greater. The age of these strata is unknown, but they generally show distinct evidence of a sedimentary origin, notwithstanding that some of the gneisses may be altered igneous (plutonic) rocks; the relation of the Cretaceous of Venezuela to them shows that they are at least early Mesozoic, and may be Palæozoic, or even Archæan, while it is very possible that parts of the Andes are older than the strata exposed in the Caribbean Hills.

The series was suitably named by Wall, as the main range of the Caribbean Hills is everywhere formed of these metamorphics, but they occur also in Margarita and throughout the Andes, while in the Llanos north of El Baul is an elevated area (known as *la Galera*) with numerous hills of similar rocks.

Next in age appear to be a group of red and yellow quartzites and sandstones with varicoloured shales and slates, and a few black bituminous limestones, often somewhat metamorphosed. These rocks cover practically the whole of the elevated region round Barquisimeto or Nueva Segovia (the Segovia Highlands), and the author therefore suggests the name *Segovia Group* for them. From several localities fossils (Ammonites, *Inoceramus*, etc.) have been obtained in them, notably near Tocuyo (by Karsten) and in the Sierra de Perija (Sievers), which show their age to range from Neocomian to Aptian (Lower Cretaceous).

In addition to their great development in the Segovia Highlands the rocks constitute a great part of the Serrania Interior, both in the Caracas and Cumaná regions, and form both flanks of the Cordillera of Merida, as well as part of the Sierra de Perija.

Above the Segovia Group in scattered areas throughout the Cordilleras there is a massive well-bedded limestone, with fossils indicating an age equivalent to the Turonian or Senonian of Europe. This limestone was studied by Dr. Sievers near Capacho in Tachira, and named by him the *Capacho Limestone*. It occurs frequently in the Cordillera of Merida, and is well seen to the east of Carache in the Humocaro Hills, where it forms castellate masses and high cliffs and gorges along the rivers. In the Segovia Highlands the Cordilleras of San Luis and Agua Negra include large masses of this limestone, and it occurs in the peninsula of Paraguana, but has been detected at only a few points in the Serrania Interior south of Caracas. In the Sierra de los Tageres it constitutes many of the ridges.

Along the western flank of the Cordillera of Merida, in the northern part of the Segovia Highlands, and throughout the Serrania Interior to the Gulf of Paria, there are belts of varying extent of a series of beds, mainly clays, with brown sandstone, carbonaceous shale, thin limestone, clay ironstone and pyrites, etc., which furnish fossils both of a high Cretaceous horizon and of Lower Tertiary age, the Cretaceous fauna being confined to the lower beds, while Nummulites and other Tertiary fossils are found in the higher strata. They are well seen in the Cerro de Oro (so called from the abundance of yellow pyrites, mistaken for gold) near Rubio in Tachira. Dr. Sievers therefore termed this group the *Cerro de Oro Series* (System). The age of the beds included under this name appears to range from Upper Senonian to Eocene, i.e. probably equivalent to other similar deposits known as Cretaceous in Trinidad.

The three geological divisions enumerated above would seem to be separated from each other only by short intervals of time, or by none at all, but there appears to be a greater difference in age between the Cerro de Oro Group and the next later series, which is markedly unconformable to all older rocks.

On the east side of the Lake of Maracaibo, and possibly on the west also, as well as on the Coro coast and over the peninsula of Paraguana, in some of the islands on the Cumaná coast, and under the Llanos, there is a series of calcareous sandstones and shales, often highly fossiliferous, which appear to correspond to the 'Newer Parian' of Trinidad. Fossils were collected from Cumaná by Mr. Wall and described by Mr. Guppy of Trinidad, between 1860 and 1870, which show the age of the beds to be probably Upper Miocene, so that our first scientific data in regard to them came from Cumaná; it seems fitting, therefore, to affix the name *Cumaná Series*.

Finally, there are two groups of strata widely different in character, but probably of the same age: one, the *Llano Deposits* (current-bedded clays and gravels surmounted by gravels), covering the whole of the great plains of Venezuela; the other a series of shell-beds with remains of mollusca little different from those now inhabiting the Caribbean Sea. These occur all round the coast from Coro eastwards, are well seen at Cabo Blanco, west of La Guaira, and form practically the whole of the island of Cubagua, whence the name *Cubagua Beds* is suggested for them. Both these groups may be taken to be of Pleistocene age, and with them should be classed the gravel and river deposits of the hills, with *Megatherium* and other mammalian remains, found near Tocuyo, the lake of Valencia, Mount Turumiquiri, and other points.

The *Recent Alluvium*, which covers so great an extent in the delta and round the lake of Maracaibo, needs no special remark.

Igneous rocks of the plutonic type also occur in Northern Venezuela, and the outcrops are in some cases of wide extent; thus, the Sierra Nevada and other regions of maximum elevation in the Venezuelan Andes are composed of a white granite, apparently of more recent date than the metamorphosed strata surrounding it. The same rock occurs under much of the peninsula of Paraguana, where there is also an intrusion of augite-porphyry in the Cerro de Santa

Ana. A rock of similar type covers a wide area in the hills south of Caracas, in the region of San Casimiro, apparently of Tertiary age, but this cannot at present be definitely stated.

III. Tectonics.

The main tectonic features of Venezuela are very simple. In the south we have the great Guayana massif, with, apparently, a general east and west strike varying to east-north-east, and with a boundary on the north side which is at right angles to the meridian. On the left bank of the Orinoco there lies the great synclinal basin of the Llanos, and beyond this again a continuous line of upheaval in the Cordilleras of the Andes and of the coast; here the strike changes, becoming approximately east and west in the Caribbean Hills, and north-east or north-north-east in the Andes, while in the intermediate highlands the strike varies from point to point. Beyond this the Maracaibo basin and the coastal plains of Coro represent a second synclinal area, while north and west of these the Sierra of Perija, the igneous masses of Goajira in Colombia, the granite and Cretaceous of Paraguana and Curaçao, and the metamorphics of Margarita, appear to mark a second anticlinal line on the northern limits of Venezuela. It will be seen that in general the structure-lines agree with the main physical divisions of the country: the upward movement which changed the Llanos region from a shallow partly-enclosed sea to broad low-lying plains was probably part of that which, beginning in the Middle Tertiary times, is still continuing to accentuate the folding of the Andes and to raise the Maracaibo region. The subsidiary movements and structure-lines have hardly been studied sufficiently to afford data for a detailed account of them.

IV. Earthquakes and Hot Springs.

While active volcanoes are entirely wanting in Venezuela, there is little lack of those evidences of internal energy so often associated with them. Earthquakes have been known in the northern part of the country from the time of the earliest settlements; thus Nueva Cadiz (on Cubagua) was shaken and the fortress of Cumaná demolished in 1530, and thirteen years later the city on Cubagua was utterly destroyed. Many shocks were experienced of greater or less violence throughout the seventeenth and eighteenth centuries, but perhaps the best known is that of March 26, 1812, when some 10,000 people perished in the destruction of Caracas. The great earthquake in South America on August 13, 1868, was as severely felt in Venezuela as anywhere, and the waters of some of the great rivers were for a short time so much affected as to overflow their banks. Great damage was done in the Andine towns in 1894, and in Caracas in 1900, while shocks were experienced in the former region during the author's visit in 1910; these were, however, unimportant as regards effect. Venezuela thus enjoys an unenviable notoriety as an earthquake country, but the shocks are remarkable for their linear character, both as regards the area in which they occur and in their effects, for practically no serious shocks have been experienced outside the region of the Cordilleras.

As associated phenomena may be mentioned the hot springs, also confined to the region of the Cordilleras. The most notable is that of Las Trincheras, between Valencia and Puerto Cabello, where the waters reach a temperature of about 195° F. or even 206° (Karsten, 1852); these springs rise through the schists and gneisses of the Caribbean Series, and they contain large quantities of sulphur. Throughout the Cordilleras many hot springs are known, and southward of Carupano one was found by Wall to be at boiling-point, while in the Andes the springs, though numerous, have in general a low temperature.

V. Economic Minerals.

On the side of economic geology Venezuela cannot be said to have been explored in more than a superficial way, leading in the first place to exaggerated ideas of the wealth of the country, in the second to an almost equally unfortunate lack of appreciation of the possibilities of its mineral wealth.

Coal has been worked at several points, though most extensively in the mines of Naricual, near Barcelona; the seams found appear to be Tertiary for the most part, and there are also Cretaceous coals. The Segovia Group may be the source at Naricual, as it is in Lara, but there is some doubt as to the age, and the Cerro de Oro Group is equally possible; in the Andes the latter has coals at many points, and there are lignites of high quality, as well as coals, in the Cumaná Series of the Coro and Maracaibo region. Iron ores have been found in many places and in rocks of every group, but have not been considered workable; the deposits of magnetite in the Guayana gneisses on the Rio Imataca seem to be of a size to warrant exploitation, and the ore is said to contain 65 per cent or more of metal.

Gold, as the metal which originally attracted European adventurers to explore these regions of South America, may be said to occur in almost every State of Venezuela, but generally in quantities too small to be more than a curiosity. Wherever the Caribbean Series forms the mass of the Cordilleras, occurrences of gold-bearing quartz are not uncommon, and near Carupano lodes have been found to yield 7 ounces to the ton. When Sir Robert Dudley visited the Paria coast in 1595 he heard of a gold-mine near Orocoa (Uracoa), on the eastern border of the Llanos, which may possibly have referred to gold-bearing gravel there, but the source of the commercial gold has always been the Guayana region, principally round the head-waters of the Cuyuni in the neighbourhood of Guacipati. Here auriferous gravels chiefly have been exploited, but the metal is derived from the Archæan immediately below. In British Guiana, where the conditions are similar, Mr. Harrison says that the gold is generally found along the basic intrusive dykes, and the veins are particularly rich where these traverse the older quartz-porphyries and felsites; the best are found near the smaller dykes.

Copper is widely distributed in the Northern Cordillera, and has been worked for many years at Aroa, where the veins of pyrites occur in metamorphosed limestone (? Capacho). At Seboruco in Tachira, in the neighbourhood of Balladores in Merida, and at many

other points in the Andes, the Caribbean Series, or the Cretaceous rocks in association therewith, contain copper ores, some of which have been worked. Galena, both argentiferous and otherwise, also occurs in the granite region of the Andes.

Petroleum, in its varied forms, occurs at many points in Northern Venezuela, and appears to exist in greater or less quantity in all groups from the Segovia Sandstones to the Cumaná Series. The asphalt of Bermudez, from the last-named series, has become widely known, and the oil of Trujillo and Tachira, from Cerro de Oro rocks, has been exploited to some extent by local companies. Sulphur is found in considerable quantity, presumably in the Capacho Limestones, both in Eastern Venezuela and in Falcon. Mention may also be made here of the 'Urao' lake at Lagunillas, near Merida, which contains a large proportion of Sesqui—carbonate of soda, rarely found in nature; and apparently in this case derived from rocks of the Segovia Group.

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IV.—The Classification of the Rocks of the Western Australian Goldfields.

By J. Allan Thomson, B.A., B.Sc., F.G.S.

(*Concluded from the April Number, p. 153.*)

Sedimentary Formations in the Goldfields.—Sedimentary rocks are rare in all the goldfields south of the Gascoyne River, if superficial deposits of Tertiary or Recent age be omitted. It is true that a sedimentary origin has at times been ascribed to the jaspers, and still more commonly to the bands of graphitic schists within the greenstones. Hand-specimens of the latter rocks and of slaty rocks associated with the jaspers are indistinguishable from similar rocks of sedimentary origin, and it is only by the study of the geological occurrence of the bands that their derivation from igneous rocks can be proved. It is probable, therefore, that many of the rocks mapped as 'older sediments' by W. D. Campbell in Kalgoorlie[1] and Norseman[2] are not sediments. There are, however, undoubted sedimentary rocks between Kalgoorlie and Coolgardie, viz. the Kurrawang conglomerates. The enclosed pebbles are largely jaspers and porphyries, so that the formation of the conglomerates must be posterior to the intrusion of the granites, and yet the matrix is sub-schistose and the axes of folding are parallel to the general direction of foliation of the district. The junction with the auriferous series cannot be seen. From the photo reproduced by Campbell, it appears that there are similar conglomerates at Norseman.[3]

It is in the north-western goldfields the sedimentary series are best developed and best exposed. Probably the oldest is a series of highly inclined quartzites, conglomerates, quartz-schists, mica-schists, etc., which is associated at Warrawoona with the basic

[1] *Geological Map of the Kalgoorlie Goldfield*, A. G. Maitland and W. D. Campbell, Perth, 1902.
[2] Bull. xxi, pp. 33–5, 1906.
[3] Loc. cit., fig. 10.

schistose rocks of the auriferous series.[1] The relationship of the two series has not been worked out, but from a consideration of the map it appears probable that the basic schists are either contemporaneous volcanic rocks or later intrusions. The relationship could be most easily solved by examining the sedimentary series for traces of contact action, and determining the nature of the pebbles in the conglomerates.

Another highly folded but probably later formation occurs in the Nullagine District, Pilbara Goldfield, and has been termed the *Mosquito* Creek Series by Maitland.[2] The rocks consist of grits, sandstones, shales, and fine conglomerates, all considerably sheared. Nevertheless, the series must be younger than the auriferous series, for the conglomerates contain numerous pebbles of the laminated jaspers of the latter, in this resembling the Kurrawang conglomerates between Kalgoorlie and Coolgardie. An observation of great interest is that the Mosquito Creek Series is intruded by a granite and forms the matrix of numerous auriferous quartz reefs.

In the West Pilbara, Ashburton, and Gascoyne Goldfields highly inclined and sub-schistose sedimentary rocks are met with at Bangemall, Uaroo, Westons, and Roeburne.[3] Besides quartz-schists, arkose, conglomerate, and phyllites, they include a large number of beds of limestones, dolomites, and cherts. At Roeburne they are intruded by dykes of amphibolites after gabbros and gabbro-pegmatites in every way comparable to rocks of the auriferous series, and probably belong, therefore, to the Warrawoona Series. At Mt. Phillips, near Bangemall, they rest unconformably upon a granite. All these rocks form the matrices of gold and copper lodes.

These highly folded beds are covered unconformably in the Pilbara Goldfield by rocks of plateau type to which the name of the *Nullagine* Series has been given.[4] Though thrown into a series of gently undulating folds the series is on the whole approximately horizontal. Besides sedimentary members such as sandstones, grits, conglomerates, and limestones, there is a well-defined volcanic series of lavas, ashes, and conglomerates. The age of these beds has been variously ascribed to Cambrian and Devonian, from lithological resemblances to fossiliferous beds of those ages in the Kimberley District. The probabilities are in favour of a Devonian age, for the known Devonian has also a volcanic series well developed.

The basal conglomerates of the Nullagine Series consist chiefly of fragments of pre-existing conglomerates, cherts, grits, and shales of the Mosquito Creek Beds, and of reef quartz, identical in character with that forming the auriferous deposits of the underlying strata.[5] They appear thus to be posterior to the main deposition of gold, but the conglomerates are themselves in places auriferous, although whether the gold is authigenous or allothigenous is a matter of uncertainty.

[1] A. Gibb Maitland, Bull. xx, pp. 57–61, 1905; Bull. xxiii, pp. 77, 79, 1906.
[2] Bull. xx, pp. 28–30, 1905; Bull. xxiii, pp. 77–9, 1906.
[3] Maitland, Bull. xxxiii, pp. 42–5, 66–7, 75–6, 99–100, 1909.
[4] Maitland, Bull. xv, pp. 10, 11, 25, etc., 1904; Bull. xx, pp. 23–8, 1905; Bull. xxiii, pp. 40–3, 77–8, 1906; Bull. xxvi, pp. 50–2, 1907.
[5] Bull. xx, pp. 24–5, 1905.

Basic Dykes.—Dykes of basic rocks are of frequent occurrence, not only in the rocks of the auriferous series, but also in the gneisses, the granites, and the older sedimentary rocks. Some of them penetrate various members of the Nullagine Series, and may be the feeders of the volcanoes of that period. The only later period of vulcanicity known in the State belongs to the Tertiary, but the rocks are confined to the Kimberley District, and very little is known about them. It is possible that the rocks under discussion belong to more than one period. All that can be said of most of them is that they are later than the folding or foliation of the granites and the deposition of the gold, and anterior to certain faults.

IV. Results of the Writer's Petrographical Studies.

The writer's acquaintance with the rocks of Western Australia commenced in London in 1908 with the preparation of a petrographical report to accompany Bulletin 33 of the Geological Survey. Some seventy rocks were examined and described in detail, but the value of the report was lessened by the writer's ignorance of the general features of Western Australian geology, and of the particular occurrence of the rocks in hand. Subsequently a year was spent (1909–10) as assistant to Dr. J. M. Maclaren in a private geological survey of Kalgoorlie, the results of which are not yet published. Some hundreds of slides of rocks from Kalgoorlie, Coolgardie, Kanaona, Leonora, and Day Dawn were carefully examined. Before leaving the State, the writer took the opportunity to look through the large series of rocks collected by the Geological Survey, and the Director, Mr. A. Gibb Maitland, kindly placed at his disposal duplicate specimens of some two hundred selected rocks, many of which had been analysed. Visits to Southern Cross and Albany made up the writer's collection to over three hundred rocks. Sections of these have been prepared and briefly examined with a view to the preparation of this paper. Finally, in Sydney the writer was able to examine, through the kindness of Professor David, a series of sixteen rocks collected by the David Lindsay Expedition to Central Australia. A paper embodying the results of this examination has been submitted to the Royal Society of New South Wales.

The majority of the rocks examined belong to the auriferous series. A large number of them are coarse-grained massive amphibolites which bear abundant internal evidence of their derivation from basic intrusive rocks such as pyroxenites, hornblende dolerites, olivine dolerites, dolerites, and quartz dolerites. The same rock species are also represented by massive chloritic greenstones and by fissile chlorite schists. Ultrabasic intrusions are represented by serpentines, talc-carbonate schists, and magnesite rocks. All these rocks appear to be intrusive into fine-grained amphibolites and chloritic greenstones that contain little internal evidence of their original structure, but must be regarded as forming a volcanic series. A distinction may thus be made between older and younger amphibolites and greenstones. Within the contact aureoles of the granites these distinctions are not so easy, for all the rocks have been transformed into hornblende and talc-tremolite schists retaining no

evidence of their internal structure, except, perhaps, the coarse or fine texture. There are only a few garnetiferous amphibolites in the Phillips River Goldfield for which a possible sedimentary origin can be admitted. An examination of the jaspers in the contact-altered schists proves that they too are contact-altered, and are therefore anterior in formation to the intrusion of the granite.

The granites and porphyries have not as yet been examined in great detail, but it appears possible to group the former into biotite-microcline granites, hornblende-granites or tonalites, and albite-granites. Each of these has its characteristic dyke accompaniment. Many of the basic dykes consist of very fresh dolerites and quartz-dolerites, and show so many points of similarity to the Karroo dolerites of South Africa and the Mesozoic dolerites of Tasmania, that it is not improbable that they are all of the same age. This view has been elaborated in the paper read before the Royal Society of New South Wales referred to above. Others are in a state of alteration intermediate between these and the amphibolites of the auriferous series.

The Nullagine volcanic rocks are entirely different in their state of alteration from the rocks of the auriferous series. They are, as far as examined, practically structureless aggregates of chlorite, epidote calcite, and quartz. Some of the rocks intrusive into the Devonian of Kimberley, however, appear to present a greater degree of constructive metamorphism. One of them is an epidosite containing an amphibole related to glaucophane.

V. Principles of Classification.

The requisites for an entirely satisfactory classification of a rock are a knowledge of—

1. Its mode of origin, whether sedimentary, volcanic, or intrusive.
2. Its age.
3. Its original lithological character.
4. Its state of alteration.

If the age is known, the rest is largely a matter of petrographical and chemical study. As far as possible the evidence for the age of each of the main groups has been discussed above, but the principles involved will be brought together here for greater clearness. It is not necessary to discuss the ordinary principles of stratigraphy by which the aid of sedimentary rocks is determined. The age of a given intrusive rock is fixed within certain limits—

1. If it can be shown to be intrusive into any rock of known age. Too great importance cannot be laid on the necessity of obtaining evidence of contact-alteration in the surrounding rocks when the intrusive nature of any rock is in doubt.

2. If it is in turn traversed by intrusive rocks of known age.

3. If it is covered unconformably by a sedimentary rock of known age. To be entirely satisfactory this evidence should be supplemented by an absence of contact-metamorphism in the overlying rocks, and by the presence of pebbles of the intrusive rock in the conglomerates of the younger series.

4. If it can be shown that its date of intrusion was before, within,

or after the period of foliation of the rocks into which it is intrusive. To attach an age significance to this relationship, it is necessary to assume that the foliation is of the same general age over the whole State. This is a perfectly justifiable assumption in the present state of our knowledge. Traces of a double foliation have been observed in gneiss at Big Sherlock River, Pilbara Goldfields, by Cadell:[1] "The older and coarser banding has a north and south strike at Big Sherlock Station, and at right angles to this there are zones of secondary and much finer foliation, within which it has the character of a mylonite," etc. With this exception there is no evidence as yet brought forward to show two distinct periods and directions of foliation such as exist in the Lewisian and Dalradian of Scotland. Variations in strike between different districts amount to nearly 90°, but whether this is due to different systems or to curving trend-lines is uncertain. A map of the State showing the trend-lines would be a great boon. For the present we may regard the foliation as of one age.

5. If it can be shown that its date of intrusion is anterior or posterior to the formation of auriferous quartz-reefs. Several distinct modes of gold occurrence exist in the State, and these may not necessarily be of the same age. Nevertheless, the presumption is, as suggested by W. Lindgren,[2] that the *mise-en-place* of the gold closely followed the intrusion of the granites, and belongs to one period.

6. If it can be shown that its intrusion is anterior or posterior to faults of known age. Little is yet known as to the age of the various systems of faults, but this line of evidence may yet yield important results.

VI. Suggested Classifications.

From the application of the above-mentioned considerations, the classification outlined below is suggested. It is put forward as a working hypothesis and will serve a useful purpose if it directs attention to the gaps in our knowledge. The rocks are arranged in ascending order of age.

I. Pre-Nullagine	A. Pre-foliation	1.	Fundamental gneisses and schists.
		2. *a*.	Warrawoona sedimentary series.
		2. *b*.	Older amphibolites (volcanic).
		3. *a*.	Later amphibolites (intrusive).
		3. *b*.	Older granites and porphyries.
		4.	Jaspers.
		5.	Mosquito Creek Series.
	B. Post-foliation	6.	Newer granites and porphyries.
		7.	Gold deposits.
		8.	Post-gold acid intrusions.
II. Nullagine Series		9. *a*.	Nullagine sediments.
		9. *b*.	Nullagine volcanics and their feeding pipes.
III. Post-Nullagine		10.	Basic dykes.

The principal gaps in our knowledge relate to the granites, porphyries, and basic dykes. These may be of many ages. Some

[1] Trans. Edin. Geol. Soc., vol. vii, p. 181.
[2] *Econ. Geol.*, vol. i, p. 530, 1906.

of the basic dykes are only known to be post-granitic, some to be post-gold, while a few are post-Nullagine. A comparison of their petrographical character and state of alteration may show whether more than one series is present, while their direction of alignment may also help to differentiate two or more series. Only one granite is definitely known to be post-Mosquito Creek, but as this sedimentary series contains gold reefs, it is probable that all the granites that can be distinctly correlated with the deposition of gold belong here. Many of the granites are rather inter-foliation than post-foliation, for they are gneissose along their margins, and the accompanying dykes are considerably sheared.

VII. Detailed Petrographical Studies.

The writer proposes to give the results of his detailed studies on the rocks of the auriferous series, the jaspers, the granites, and the basic dykes in subsequent papers. As a contribution to the knowledge of the fundamental gneisses the following is offered. Little is known of the geological occurrence of these rocks, but their structures favour the view that they are highly metamorphic.

G.S.M. 832. (This and subsequent numbers refer to the Register of the Geological Survey Museum, Perth.) This is a well-foliated biotite-microcline gneiss from Loc. 1046, N.W. of Mt. Dick, Mortlock River, Northam, i.e. in the western granite belt of Woodward. The darker layers owe their colour to small plates of biotite aggregated more or less in bands, and lying with their cleavage planes in the planes of foliation. In the lighter-coloured layers quartz and felspars predominate. A plagioclase (oligoclase-andesine) occurs sparingly in large elongated and much striated crystals with its longer axes in the planes of foliation. Quartz also occurs in elongated and similarly oriented crystals, separated by numerous small rectangular plates of microcline. An interesting feature in the slide studied is a graphic intergrowth of two adjacent crystals of quartz. Iron-ores are practically absent and accessories rare. The rock has the composition of a microcline granite and the structure of a gneiss.

G.S.M. 2286[1] is a hornblende-biotite gneiss from Dalgety Creek, Lyons District, east of Gascoyne. It is not so perfectly foliated as the preceding rock, for the biotite plates follow the boundaries of large rounded slightly sericitic oligoclase crystals. Both the felspar and the biotite exhibit bent cleavage-planes and twin-planes and undulose extinctions. The biotite is frequently crowded with rutile, sometimes in small stout prisms, at other times in hair-like sagenitic needles. Quartz is fairly abundant in small clear anhedral plates between the felspars. There are no minerals with refringence less than that of balsam, so that potash felspars are absent. A green hornblende, subordinate in amount to the biotite, occurs in small euhedral prisms. Apatite is the only accessory.

G.S.M. 8692, from Goddard's Creek,[2] in the south-eastern corner of

[1] Some confusion exists as to whether the section described really belongs to 2286, owing to a mistake in labelling by the lapidary.

[2] Cf. Bull. xxxvii, pp. 14–15, 1909.

the State, is not a well-foliated rock, but has both the mineral composition and the structure of a typical crystalline schist. The minerals noted are garnet, biotite, sphene, apatite, a plagioclase near andesine, orthoclase, and quartz. The garnet is not distinctly euhedral, and is full of inclusions of the other minerals. Sphene occurs in small characteristic acute prisms. The chief structural peculiarities are the frequent inclusion of quartz in rounded plates within the orthoclase, and the presence of intergrowths of quartz and plagioclase (Fig. 1).

These intergrowths have the gridiron shapes characteristic of 'myrmekite', rather than the script-like forms that have given rise

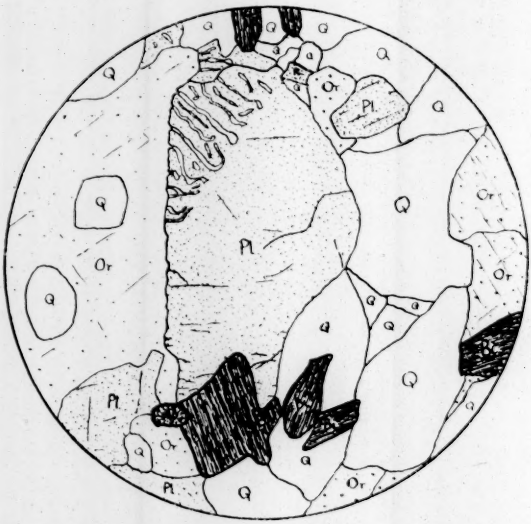

FIG. 1. Gneiss showing the inclusion of quartz in orthoclase and a myrmekitic intergrowth of quartz and andesine. Magnification, 42 diameters. Ap. = apatite ; Bi. = biotite ; Pl. = plagioclase ; Or. = orthoclase ; Q. = quartz.

to the term 'graphic'. They are strictly confined to the plagioclase. Myrmekite in Sweden is considered a sign of extreme metamorphism and great age in granite.[1]

Two rocks collected by the writer on the beach between Albany and the Pier resemble the last-described rock in both these structural features, viz. the inclusion of quartz in orthoclase and the myrmekitic intergrowth of quartz and a plagioclase near oligoclase in composition. They are hornblende-biotite gneisses, with hornblende in equal or greater amount than biotite. A further structural peculiarity is the occasional presence of myrmekitic intergrowths of quartz and biotite (Fig. 2) and quartz and hornblende.

[1] J. P. Holmquist, "Studien über die Granite von Schweden": Bull. Geol. Inst. Upsala, vol. vii, p. 116, 1904–5.

Orthite occurs in the centres of fairly large prisms of epidote, and has determined pleochroic haloes in the biotite. Zircon and apatite are abundant in minute prisms. Of these rocks, the one is well foliated, the other massive, and mineralogically they differ chiefly in the larger amount of hornblende compared to biotite in the latter. The massive rock might easily be taken in the hand-specimen for an ordinary granite, but from its structural peculiarities must be assigned to the gneiss complex, which at Albany is intruded by a coarsely porphyritic pink granite of probably much later age. Among the gneisses garnetiferous varieties were seen, but have not been studied in thin section.

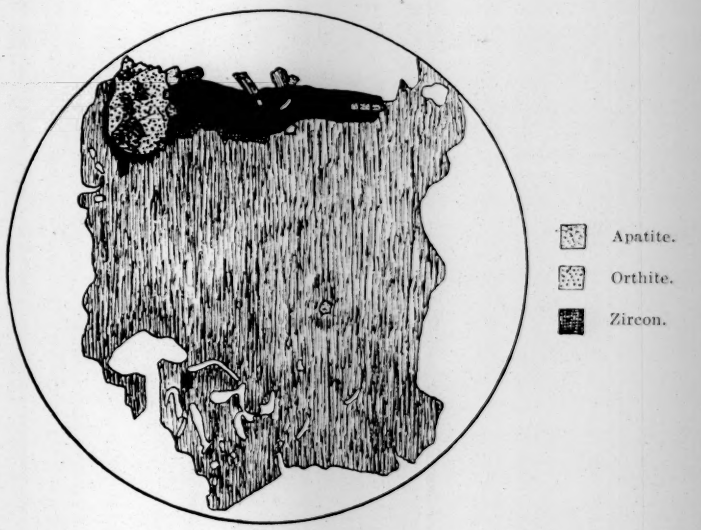

FIG. 2. Detail from gneiss showing biotite myrmekitically intergrown with quartz in the bottom left-hand corner and associated with and partially enclosing orthite, apatite, magnetite, and zircon. Magnification, 34 diam.

The writer's thanks are due to Messrs. A. Gibb Maitland, Harry P. Woodward, and C. G. Gibson for unfailing kindness during his residence in Western Australia, and for much verbal information which has enabled him to form clear views on the geology of districts which he has not been able to visit. To Dr. J. M. Maclaren, also, he is indebted in a manner difficult to estimate, since most of the above ideas were freely discussed with him during a year's close association. None of these gentlemen, however, can be committed to the classification outlined above.

V.—Some Handiworks of Early Men of various ages.

By the Rev. O. Fisher, M.A., F.G.S.

(WITH FOUR TEXT-FIGURES.)

IN the following notes I propose to chronicle a few works of early man other than chipped flints in this country, which during a long life have come under my own observation. They shall be arranged in order of antiquity, and, as might be expected, the earliest will be the most doubtful. Nevertheless, in anticipation of its being possibly confirmed by future discoveries it shall not be passed over.

1. When digging for fossils in the Eocene of Barton Cliff I found a piece of a jet-like substance about 9½ inches square and 2¼ inches thick. There was a large oyster-shell attached to the upper surface. It bore on at least one of its sides what seemed to me to be marks of the chopping which had formed it into its accurately square shape. This specimen is now in the Sedgwick Museum, Cambridge.

2. The next in antiquity was the cut bone from the Crag, which I first saw in the collection of Mr. Whincopp, of Woodbridge, and which he called a bludgeon. It afterwards passed into the hands of Sir Joseph Prestwich, and is now in the British Museum. It was described by me and is figured in this Magazine[1] (Fig. 1).

Fig. 1. Piece of a fossil rib, partially sawn across at both ends. From the Red Crag. Part of the late Mr. Whincopp's collection. Scale 2 inches to a foot.

The suggestion that man could have existed in Pliocene times was of course received with due scepticism; but the recent discovery of worked flints from the Crag[2] is in remarkable accordance with the supposition that the thing was the weapon of a human being of that period. The two finds confirm one another.

3. The next in order of time is a work of a different character. I refer to the elephant trench at Dewlish in Dorsetshire. This trench was excavated in chalk and was 12 feet deep, and of such a width that a man could just pass along it. It is not on the line of any natural fracture, and the beds of flint on each side correspond. The bottom was of undisturbed chalk, and one end, like the sides, was vertical. At the other end it opened diagonally on to the steep side of a valley. It has yielded abundant remains of *Elephas meridionalis*, but no other fossils. I have described it with two photographic views in the Journal of the Geological Society,[3] and it may be noticed that in one narrow place the sides mutually approach one another, a feature

[1] 1905, p. 575. [2] Moir, Proc. Prehistoric Soc. of East Anglia, 1911.
[3] Q.J.G.S., vol. lxi, pp. 35–7, 1905.

which can hardly be explained by any natural process. This trench, in my opinion, was excavated by man in the later Pliocene age as a pitfall to catch elephants; and, if so, it proves that he was already an intelligent and social being, because no single hand could have accomplished so great a work.

4. Excepting stone the most enduring substance employed by primeval man was bone, and the instance of the use of this material that first came under my observation was the cut rib bone, supposed of an elephant, found by Blake in the gravel of Barnwell near Cambridge, and described by the late Professor H. G. Seeley.[1] This bone was not sawn, but notched round and then broken. The gravel at this locality contains *Elephas antiquus* and the southern shell *Cyrena fluminalis*.

FIG. 2. Base of shed antler of red deer (*Cervus elaphus*) from Barrington. Circumference above burr, 9 inches. Antlers partly sawn and then broken off.

5. The terrace of gravel at Barrington,[2] which is about seven miles from Barnwell higher up the drainage system, has been extensively excavated, and has yielded many well-preserved mammalian remains, of which a large number are in the Sedgwick Museum at Cambridge. The species of elephant is *E. antiquus*, but *Cyrena fluminalis* does not occur. Several bases of deer's antlers have been found here, from which the branches and tines have been sawn off. One of these in the collection of the Rev. E. Conybeare is now figured (Fig. 2). This was a shed horn, but some of the bases have portions of the skull attached, which shows that the animals had probably been killed. In the *Geologist* for 1861[3] I have described and figured such a specimen, which evidently had been chopped off the skull, the marks of chopping

[1] Q.J.G.S., vol. xxii, p. 470.
[2] See Professor Hughes, Proc. Geol. Assoc., vol. xxii, pt. v, 1911.
[3] *Geologist*, vol. iv, pp. 352–4, pl. ix, 1861.

being distinct. It was dredged up at a spot called the Wallet, off Clacton, in dredging for cement stone, and was in the possession of Dr. Bree, of Colchester. *Cyrena fluminalis* occurs in the Pleistocene cliff at Clacton, which seems to correlate the deposit with the Barnwell gravel.

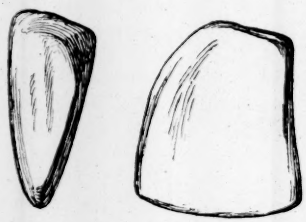

FIG. 3. Piece of red ochre cut into shape for marking lines, from Grantchester. Length, 1 inch ; width, $\frac{3}{4}$ inch ; $\frac{3}{8}$ inch in thickness at butt end.

Probably in these cases the antlers were cut off for use, and the bases thrown away. I have not seen any fossil antler. We know that the antlers of red deer were used as picks by Neolithic man, because they have been found in the flint-mines at Grime's Graves near Brandon. What saw did these ancient people possess? That it was not very efficient is shown by the marks it has left, and they seem to have saved themselves the trouble of sawing as soon as the object could be broken.

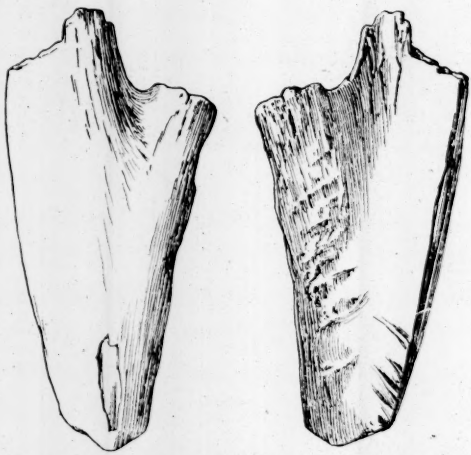

FIG. 4. Cut fragment of bone from Bedfordshire. Reduced to two-thirds natural size.

6. At one time, when I was digging for bones in the gravel at Barrington,[1] I found two round stones of the same size near one another. One of them was a flint nodule, the other of a different rock. They attracted my attention at the moment, but their possible

[1] Q.J.G.S., vol. xxxv, pp. 670–7, 1879.

significance did not occur to me then, and I did not preserve them. I afterwards thought that they might have been bolas, such as are used in South America for catching game. They were of a suitable size for such a purpose.

7. During the time when the Upper Greensand of Cambridgeshire was being extensively worked for phosphatic nodules (miscalled 'coprolites'), a pit was opened in 1880 near Grantchester vicarage house.[1] The heading consisted of a bed of gravel containing teeth of *Elephas primigenius* and among others many shells of *Cyrena fluminalis*.

At a depth of 12 feet in this gravel was found a piece of red ochre, cut into a form somewhat similar to that into which tailors cut french chalk for marking cloth, a form especially suitable for drawing lines. Its specific gravity is about 4·5. It is now figured

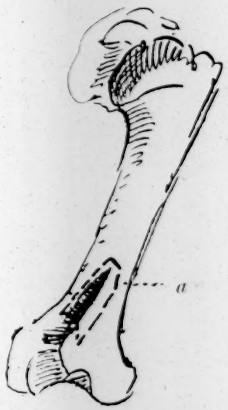

FIG. 5. Rough sketch to show "Lower end, posterior part of left humerus of a large ungulate, probably *Bos taurus*, showing the part (*a*) from which the above fragment (see Fig. 4) was obtained; the hollow is part of the natural configuration of the bone" [W. L. H. D.].

(Fig. 3). It is an inch long, three-quarters of an inch wide at the edge, and three-eighths thick at the back. I sent this specimen to Professor Boyd Dawkins for his opinion, and he replied that a bit of 'raddle' had been found in the Creswell Caves, and that "he had no doubt that the palæoliths raddled themselves". Frequent mention of the use of this material will be found in that instructive work, Sollas' *Ancient Hunters*. An interesting point about this find is that it indicates traffic at that early period between distant places, because this mineral does not occur anywhere near, but must have been brought from a great distance. At present it is mostly obtained from the Mendip Hills in Somersetshire.

8. On a heap of gravel brought to repair the line at Lord's Bridge Station on the Cambridge and Bedford Railway, I found the piece of

[1] See an exhaustive paper on the Pleistocene Mollusca of the neighbourhood of Cambridge, by Mrs. McKenny Hughes, this Mag., 1888, p. 191.

bone now figured (Fig. 4). It is of a brown colour and much mineralized. I was told that the gravel came from Bedfordshire, possibly from the Biddenham pits, where Mr. Wyatt obtained many flint implements. It shows at one end cut marks on both surfaces. Dr. Duckworth informs me that it is from the lower end of the posterior part of the left humerus of a large ungulate, probably *Bos taurus*, and he has pointed out the position of the fragment (Fig. 5), showing that the hollow, which so conveniently fits the fore-finger and causes the thing to lend itself so readily to the hand, as Sir Joseph Prestwich remarked to me, is a part of the natural configuration of the bone. It does not seem probable that a fragment of that shape should splinter off such a bone unless it was broken intentionally. The article seems just suitable to be used spoon-fashion, and it would serve well for scraping the marrow out of a split bone. If that was its purpose, I think it is a rare instance of finding a Palæolithic implement intended for personal convenience.

VI.—The Plates of the Buccal Membrane in *Echinocorys*.

By Herbert L. Hawkins, M.Sc., F.G.S., Lecturer in Geology, University College, Reading.

A SPECIMEN of *Echinocorys* showing the plates of the peristome was exhibited at the Conversazione of the Geologists' Association in 1910 by Mr. W. H. Bennett, and has, through the courtesy of that gentleman, been forwarded to me for detailed examination. In view of the perfect preservation of the peristomial structures, and the extreme rarity of their discovery, I have thought it advisable to publish the following short description. A comparison is made between the structure shown in this specimen and that described by Lovén in the young stages of *Echinocardium*.

Description of the Test. The broken test, of which only the anterior part of the base is preserved, was found by Mr. Bennett on beach reefs 100 yards east of the steps at 'Black Rock', Brighton, in the upper part of the zone of *Marsupites*. The form would seem, judging by the fragment remaining, to have been a characteristic example of the variety of *Echinocorys vulgaris* called *pyramidatus* by English workers, this variety being almost restricted to the *Marsupites*-zone. The base is almost flat, and the sides are curved up from it through rather more than a right angle, making the edge of the adoral surface coincident with the greatest width of the test.

The flatness of the base is interrupted around the peristome, which is situated in a considerable hollow. The portion of the test between the anterior margin and the peristome is inclined sharply towards the interior of the Echinoid, and on the other side of the peristome the plastron rapidly regains the ambital level. Part of the concavity thus formed contains the large podial pores and their attendant tubercles, the deepest part alone being occupied by the peristome.

The Shape of the Peristome. The peristome is a roughly elliptical aperture, whose greatest width (transverse measurement) is 6·1 mm. This diameter is towards the posterior part of the opening. The greatest length (antero-posterior measurement) is 4·4 mm., this being

absolutely on the long axis of the test. The area of the peristome is not flat, and hardly in any part parallel with the adoral surface of the test. The most deeply sunken part is at the anterior margin, and, with the rest of the test, the edge of the peristome curves sharply up towards the plastron from about the region of its greatest width. This feature is indicated in Fig. 1, B. The actual margin of the peristome is visible in the specimen under description only in its posterior part, being overlapped anteriorly by the peristomial plates. This is probably due to the warping of the membrane on which these plates were fixed. In ordinary specimens, however, the margin is completely smooth, without any trace of sockets for the articulation of the peristomial plates.

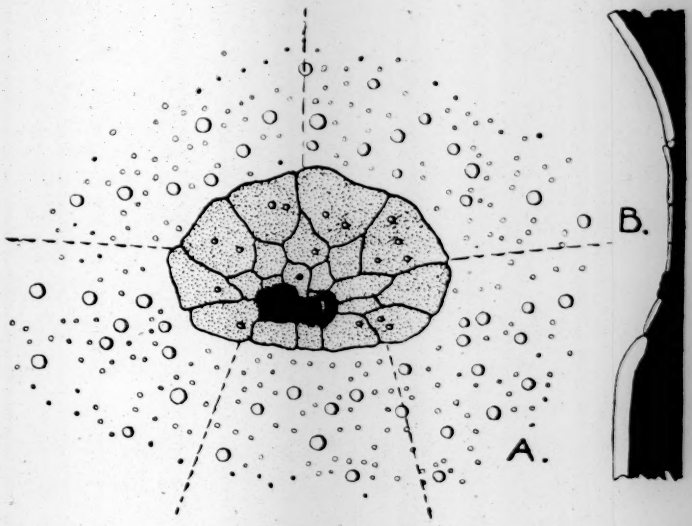

FIG. 1. Plating of the buccal membrane in *Echinocorys*. A, camera lucida drawing, × about 6·5; B, sectional view, diagrammatic.

The Peristomial Plates. The plates of the peristomial membrane are preserved in situ, the slight displacements that they show being probably due to the inward contraction of the membrane after death. They are polygonal, mostly pentagonal, in shape, and seem to be exceedingly thin. The surface of all of them is finely shagreened, in contrast to that of the coronal plates, which are almost smooth between the miliaries.

The outer ring in contact with the margin of the peristome consists of eleven plates of considerable size and very regularly disposed. The sutures between them are approximately continuous with the perradial and interradial sutures of the test. The four largest plates of this cycle are towards the anterior edge, and correspond in position to the anterior radius and the two antero-lateral interradii. They are pentagonal, and, while opposing straight edges to one another, have a slightly sinuous outline externally. This probably means that

they were not actually articulated to the peristome margin, which, in fact, they overlap. Posterior to these four large plates are a pair (on each side) of transversely elongated plates, very obscurely pentagonal, which correspond to the antero-lateral and postero-lateral radii and the included postero-lateral interradii. Three more or less quadrangular plates of about the same size as the last (they are foreshortened in Fig. 1, A) complete the cycle in its posterior portion. The smallest of the three is on the antero-posterior axis, so that the outer cycle is approximately bilaterally symmetrical. Many of the plates support one or more miliary granules.

The second cycle is incomplete, as far as the evidence of the specimen shows. It is composed of six elongately hexagonal plates, alternating in position with those of the outer ring. Only the anterior (radially situated) member of this series supports a granule.

The third cycle is very incomplete, consisting of three plates (with traces of a fourth) of somewhat irregular shape. The central plate has a deep hollow on it, which is probably a pore, but, as the specimen is preserved, bears considerable resemblance to a spheridial pit.

Owing to the restriction of the two interior cycles of plates to the anterior part of the peristome, the actual mouth opening is driven to the posterior half of the membrane. The smaller plates are to some degree collected round the position of the mouth in a slightly elevated cone. The mouth is situated at the foot of the sharp outward curve of the posterior part of the peristome, but is not in the deepest part of the concavity.

Comparison with peristomial plates in Echinocardium. The primitive position among the Spatangoida occupied by the Echinocorythidæ is well illustrated by a comparison of the plating of the buccal membrane in the specimen described with that of *Echinocardium*. A characteristic feature in the evolution of the Spatangidæ is the gradual increase in prominence of the labrum, and the consequent restriction of the peristomial opening to a crescent shape, when viewed from below. The zonal sequence of the *Micrasters*, as described by Rowe, illustrates this tendency very clearly.

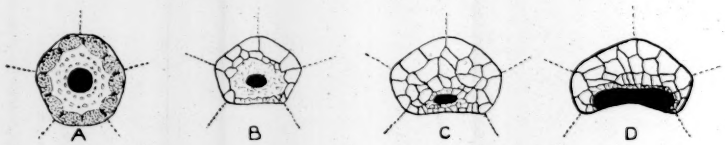

FIG. 2. Stages in development of buccal membrane in *Echinocardium flavescens*. A, in a very young specimen; D, in an adult. Modified from Lovén, *On 'Pourtalesia'* and *Études sur les Échinoïdées*.

Lovén has shown that in the ontogeny of *Echinocardium flavescens*, the peristome is central in the early stages, and retains its position (relative to the anterior margin) throughout growth, its later eccentricity being due to the disproportionate increase of the posterior part of the test. In two of his works (*On 'Pourtalesia'* and *Études sur les Échinoïdées*) he gives beautiful figures of the buccal plating in

that species at various stages of its development. They are copied (somewhat diagrammatically) in Fig. 2 for purposes of comparison.

In the earliest stage (Fig. 2, A) the buccal membrane of *Echinocardium* is roughly decagonal in outline, and supports three cycles of plates. The inner cycles are rather irregular, but the outermost cycle is composed of ten large reticulate plates (apparently in a continuous ring) corresponding in position with the ends of the ten ambulacral columns. In all probability these buccal plates actually represent the primitive terminals of the radial plates, as in a young Diademoid. Their correspondence in position with the 'buccal plates' of *Conulus* is noteworthy, but the massive character of the latter ossicles renders their correlation with those of Spatangoids very doubtful.

In the next stage figured by Lovén, the peristome of *Echinocardium* is seen to be truncated posteriorly by the incipient labrum (Fig. 2, B). This change in shape has disorganized the plating of the buccal membrane, but only to a slight degree in the anterior region, where, for the most part, two large plates of the outer cycle intervene between each radius. The posterior part of the cycle is built of small, irregular plates. In the third stage (Fig. 2, C) the labrum has progressed to such an extent that the mouth opens very near to the posterior margin of the peristome, from which it is separated by a few minute and irregular plates. The disarrangement and multiplication (or perhaps subdivision) of the anterior and lateral plates of the outer cycle is not seriously increased from the degree attained in the second stage.

In the adult Spatangid (Fig. 2, D) the labrum has so far extended forwards that the mouth (now much enlarged) opens directly against the posterior edge of the peristome, and the only remaining buccal plates are anteriorly and laterally situated. The chief modification that has affected these residual plates is that they have become subdivided, so that three new plates represent two original ones in the two anterior sections. In the postero-lateral interradii, the lateral members of the cycle are still in the original dual grouping.

The buccal characters, both in peristome-shape and plating, in *Echinocorys* correspond to a stage intermediate between the first and second in *Echinocardium*. The primitive three cycles are quite clearly, and solely, represented in *Echinocorys*, but the ingress of the posterior margin of the peristome, while destroying the inner cycles of plates in that region, has caused a subdivision of the two posterior plates of the outer cycle into three.

Since the specimen described above is the only one in which the buccal membrane plates of a Cretaceous Spatangoid are known (so far as I am aware), it is interesting to find that the palæontological evidence is in such direct accord with that derived from ontogeny. It is probable that species corresponding to the later, and perhaps the earlier stages in *Echinocardium*, will be found among Cretaceous and early Tertiary Spatangoids.

REVIEWS.

I.—Observations on the West of England Mining Region. By J. H. Collins, F.G.S. 8vo; pp. xxi, 683, with 18 plates. Plymouth: William Brendon and Son, Ltd. 1912.

THIS substantial book, issued as volume xiv of the Transactions of the Royal Geological Society of Cornwall, embodies the results of the author's long-continued personal observations and researches on the mineral deposits and mining geology of Cornwall and parts of Devon and West Somerset. Remarkable as it seems, the author affirms that the germs of most of the generally accepted conclusions on the origin and development of the ore-deposits were put forth by geological writers in the eighteenth century. These were amplified later on and established by Carne, R. Were Fox, De la Beche, Henwood, and others, while the details of Nature's methods have been dealt with by more recent writers. The 6 inch Geological Survey of Cornwall, commenced in 1897 by Mr. Ussher in East Cornwall and by Mr. J. B. Hill in West Cornwall, has been completed so far as the mining areas are concerned, and all known particulars relating to active and abandoned mines, with sections and plans, have been published. The work, indeed, has been carried as far as Tavistock in Devon.[1] Referring to this undertaking the author observes that "The recent re-survey of our area, besides clearing up many stratigraphical problems, has thrown much light on its petrography", but he, rather humorously, adds "That as regards our ore deposits it has propounded more problems than it has solved".

It is admitted that the oldest rocks determined by fossil evidence are Ordovician, and that there is little doubt that there are earlier rocks at Start Point, the Lizard, and elsewhere in West Cornwall, rocks which are not metalliferous to any important extent. In 1881 the author first called attention to the possible Cambrian age of the rocks on the western borders of the Falmouth estuary at Ponsanooth[2] (siliceous slaty rocks since grouped by Mr. Hill with the Mylor Series), but in the present work the author does not particularly refer to them, nor does he mention the Silurian rocks discovered by Mr. Upfield Green and Mr. C. D. Sherborn at Porthluney and Porthalla.[3] The fossiliferous Ordovician rocks of Perhaver, Gorran Haven, are regarded by Mr. Philip Lake as 'apparently Llandeilo'.[4] These conclusions are important as the field-evidence obtained by the Geological Survey indicates the proximity on the one hand of the relics of Silurian strata to the Gorran quartzites, and on the other hand the downward succession from the quartzites to the Veryan limestones, cherts, etc., Portscatho, Falmouth, and Mylor Series; so that these divisions are not probably 'Upper

[1] See Notice of Memoir on Tavistock, etc., p. 227.
[2] Journ. Roy. Inst. Cornwall, vii.
[3] Geol. Mag., 1906, p. 33.
[4] C. Reid, *Geology of Mevagissey* (Geol. Survey), 1907, p. 39.

Silurian', but of older Palæozoic age than the Veryan Series, which is regarded as Ordovician by Mr. Howard Fox.[1]

These questions, dealt with mostly in footnotes by the author, are not of great concern in connexion with the main object of his work. With regard to the age of the ore-deposits he states: "That much of the iron oxide, iron and copper sulphide, and oxide of manganese of the Devonian and Carboniferous rocks appears to be pre-granitic in origin. On the other hand there is very little reason for supposing that there was any tin in the rocks before the granite was intruded."

The mode of occurrence of the ore-deposits, the earth-folds and faults, together with the granite intrusions, are described, and full particulars are given of the carbonas, stockworks, and floors. The lode-fillings and modifications in adjacent country rocks, the sources and distribution of ores and vein-stones, the relative ages of elvans and lodes, and the detrital ore-deposits all receive attention.

The area dealt with extends from Ashburton in Devon to the Land's End, and the author gives a general account of each mining district or chief group of mines, with instructive details illustrated by maps, sections, and plans of particular mines, the district of Camborne and Illogan being regarded as "almost equal in importance to all the remainder of the regions taken together". Outlying mineral areas are likewise dealt with, including the Brendon Hill iron-lodes, the Brixham iron-mines, the Upton Pyne manganese-ore, etc. Subterranean water-circulation and thermal waters are also described. There is an Alphabetical List of Mines, with statistics of production; and there are tables of the occurrence of minerals in different rocks and in successive deposits in veins or fissures. A good index completes this eminently practical volume.

II.—Geological Survey of Great Britain.

1. The Geology of the Country around Tavistock and Launceston. By Clement Reid, F.R.S., G. Barrow, F.G.S., R. L. Sherlock, D.Sc., D. A. MacAlister, A.R.S.M., and Henry Dewey, F.G.S. 8vo; pp. vi, 144, with 3 plates and 48 text-illustrations. 1911. Price 3*s*.

A GLANCE at the excellent colour-printed map (Sheet 337, price 1*s*. 6*d*. net) which accompanies this memoir indicates the many important additions made to our knowledge of the country since the 1 inch geological map of De la Beche was published. The contrast is shown in the subdivisions of the igneous and metamorphic rocks in the Culm Measures and valley deposits; at the same time not so many divisions are distinguished on the map as are stated in the table (p. 2) to be so represented. There is no doubt that the area is one of the most difficult in Britain to interpret owing to successive earth-movements prior to and during the intrusion of the granite masses, and subsequently. So that with faulting, irregular

[1] See J. B. Hill and D. A. MacAlister, *Geology of Falmouth and Truro* (Geol. Survey), 1906, pp. 15, 19.

packing, and overthrusting, the true sequence of the several subdivisions in the Upper Devonian is not manifest, nor are the relations clear between Devonian and Lower Culm Measures, nor between the Lower and Upper Culm Measures. The general sequence, however, appears to coincide very fairly with that given by John Phillips from the Upper Devonian Petherwin Group with *Goniatites* and *Clymenia*, to Carbonaceous or Culm Measure shales, shales with limestone, and Coddon Hill chert series; and he observed appearances of some unconformity between the base of the Culm Measures and the Petherwin Group. The extension of the chert beds is well shown on the new map by a bright yellow tint, and they are regarded as probably belonging to the Upper Limestone Shale, a position equivalent to that of the Pendleside Series, assigned to the Coddon Hill Beds by Dr. Wheelton Hind.[1] With regard to the origin of the chert, the authors of the present memoir remark that "the chert seems to be an altered shale of very fine grain, containing a considerable number of radiolaria, but generally without the calcareous foraminifera and other calcareous organisms which must have accompanied them. The preservation of the fossils was apparently due to silicification of the rock at an early date, before the radiolaria had disappeared, but after the calcareous organisms had been removed". In this view the authors differ from Dr. G. J. Hinde and Mr. Howard Fox, who regarded the cherts as "essentially of organic origin".

There is much of interest in the accounts of the volcanic rocks with pillow-lavas in the Upper Devonian of Tavistock and in the Lower Culm Measures of Brent Tor and elsewhere. That some of the igneous areas are complicated enough may be judged from the description of a large road-stone quarry at Newbridge, south-west of Callington. There "in the quarry itself the rocks are seen to be greatly disturbed. At its entrance an outcrop of slate has been converted to spilosite through contact with an intrusive basic igneous rock which appears through the floor of the quarry on the western side. Chert is found in the lava on the eastern side near a small fault. Above the spilosite, on the western side, lava and chert are in juxtaposition, but the junction between them and the slate is a disturbed one. Further in the quarry this lava is found to be a prolongation of the main mass. A little spilosite is found above the lava, but the rest of the quarry inwards consists almost entirely of fresh vesicular lava".

The association of contemporaneous volcanic rocks with the Culm Measure chert is interesting, and suggests to the authors some possible connexion between the submarine eruptions and the silicification before mentioned. The greenstones, the polyphant stone (a serpentinized picrite),[2] the granites and elvan-dykes, and the metamorphic aureole are duly described.

There is no great amount of valley drift, but it comprises gravel, alluvium, and peat, and there is also some hill-peat. Stream-tin and

[1] GEOL. MAG., 1904, p. 400.

[2] The paper by Mr. J. H. Collins on Cornish Serpentinous Rocks, GEOL. MAG., 1886, p. 366, has apparently been overlooked; see also Collins, Journ. R. Inst. Cornwall, vol. xxiii.

wolfram have been obtained from the alluvial deposits on and near to the Bodmin Moor granite. A full account is given of the various mines of tin, copper, lead, silver, manganese, etc., with plans and statistics. Building-stones, slates (mostly Carboniferous), and other economic deposits are described, and a short account is given of water-supply derived from granite areas.

III.—Geological Survey of Great Britain.

2*s* The Geology of the Country around Ollerton. By G. W. Lamplugh, F.R.S., J. B. Hill, R.N., W. Gibson, D.Sc., R. L. Sherlock, D.Sc., and B. Smith, M.A. 8vo; pp. v, 93, with 6 text-illustrations and 4 plates. 1911. Price 2*s*.

OLLERTON is situated on the Bunter Pebble-beds of Sherwood Forest, and lies in the northern part of the area represented on the colour-printed map, Sheet 113, accompanying this memoir.

The area is formed almost wholly of Permian and Triassic strata, for there is but a tiny portion of Lower Lias in the south-eastern corner, and the Coal-measures, worked at Warsop, do not appear at the surface, although they extend beneath the entire area probably at a depth which nowhere exceeds 4,000 feet. The map shows the Drifts, but we have never seen a 1 inch sheet with glacial deposits, which shows less Boulder-clay, gravel, and sand. The Trent River on the east is naturally bordered by Alluvium and Valley gravel; there are tracts of tufa in the Alluvium near Caunton and Tuxford, and there are deposits of Blown Sand bordering the Trent and apparently derived from the river flat.

An interesting marine bed is described as occurring above the Top Hard Coal in a shaft at Mansfield Colliery, the most abundant fossils belonging to species which occur below the Millstone Grit. Some differences of opinion are expressed with regard to the relations between Permian and Trias. Mr. Hill sees local indications of unconformity, whereas Dr. Sherlock considers that the upper part of the Permian in the northern district is equivalent to the lower part of the Bunter further south. The Bunter Pebble-beds, which yield a dry sandy soil, extend through that part of Sherwood Forest known as the 'Dukeries', and noted for its beautiful parks and fine timber. The lower portion of the Keuper is termed 'Waterstones', though Lower Keuper Sandstone would seem a more appropriate general term. The Keuper Marls contain gypsum and layers of hard dolomitic sandstone or 'skerries', the outcrops of which are indicated on the map by lines. Rhætic beds occur over a small area, including the *Avicula-contorta* shales and overlying marls and pale limestone that, despite the doubts of Mr. L. Richardson, may reasonably be regarded as representing the White Lias.

We are glad to see attention given to the organic remains (mammals, mollusca, and plants) of the Alluvial deposits, including also human remains and celts. The older Valley gravels do not appear locally to have yielded any fossils, but the authors discuss the changes indicated since the river was established. Economic geology has a useful section on soils and agriculture; there are records of

borings and sinkings; and a Bibliography forms the concluding portions of this memoir.

The illustrations of 'Rock-houses' in Bunter Pebble-beds, and of the 'Druid Stone', a cemented mass of gravel at Blidworth, of the quarries in Bunter for moulding-sand and in Keuper Marl for gypsum, are interesting, but in our copy they are poorly printed.

IV.—Faults and Dykes: A Geological Study of the Witwatersrand. By John S. Olver. 8vo; pp. vii, 298, with 62 text-illustrations and 6 plates. London: The Mining Magazine, Salisbury House; Cape Town, J. C. Juta & Co., 1911. Price 21*s.* net.

THIS is an expensive volume, judging from the amount of letter-press and illustrative matter. These are well printed, but the figures and diagrams are not properly numbered and there is no index. The work, however, is one which has important practical applications in the gold-mining area of the Rand, and should be of essential service to those engaged in the economic working of mines and in the development of fresh areas.

The author commences in Part I with descriptions of faults, normal and reversed, and of dykes which may be simple fissures or faults filled with intrusive igneous matter. Various diagrams and calculations are given with respect to fault-movements and slides or slide-thrusts, and he observes that thrust movements on the whole are much greater than the throws of ordinary faults. Attention is called to the importance of observing all phenomena connected with displacements, such as the presence or absence of drag; the effects of tilting on normal faults; the character of the material with which the fissures are filled, as a means of identification; whether water-bearing and if water ceases to flow from higher levels when tapped below; and the relative ages of the disturbances. It is observed that quartzites and bankets are best examined when wet, dykes when dry; that cleaved quartzites are suggestive of the proximity of an important fault. The character and composition of reefs, especially the size of pebbles, are important in identifying particular bands. The author remarks that "There appear to be a few well-attested cases on the Rand in which a dyke has been found to carry an appreciable amount of gold, and it seems not at all improbable that such a dyke would enrich the reefs in contact with it". He concludes, however, "that intrusive igneous matter has played a very small part in the introduction of gold into the banket." Finally, hints are given on mine-sampling.

Part II contains a particular account of the geology of the Central Witwatersrand, illustrated by maps and sections. In his concluding remarks the author states: "There appears, in fact, to be no basis whatever for the traditional belief that the further course of the Rietfontein Reefs must be towards the east. The only local evidence of value points in a north-easterly direction. Whether the author's theory with regard to a northern outcrop of the Main Reef Series is sound or not can only be proved by actual boring operations, but it can be confidently claimed that the balance of evidence at present available is overwhelmingly in favour of the theory." While

discussing the views of other observers he does not give a single footnote reference to their publications.

V.—Cambridge County Geographies.

OF this series we have received the volumes relating to Buckinghamshire by Dr. A. Morley Davies (1912), Northamptonshire by Mr. M. W. Brown (1911), and Midlothian (Edinburgh) by Mr. Alex. McCallum (1912). As would be expected, the physical features, geology, and soils of Buckinghamshire are well described, and also illustrated by longitudinal sections and views of quarries. The geological map, as in the other volumes, does not show the Drift deposits, but descriptions are given of Boulder-clay and gravel. The economic uses of the various formations, including greywethers, are noted, as well as the relations of the plants to the soils and subsoils. There are good views of river scenery and an interesting map showing the distribution of streams, and their absence over the higher Chalk tracts; also views of lynchets and of the old 'ridge and furrow' method of draining clay lands.

Northamptonshire has not such an extended series of geological formations, but the map is more detailed than that of Buckinghamshire. Views are given of river scenery and floods, of ironstone workings at Islip and iron-works at Corby, of a stone quarry at Weldon, and the splitting of Collyweston slates. Some Palæolithic and Neolithic implements are also figured.

In the excellent account of Midlothian there is much to interest in a maritime, agricultural, and industrial county. The formations extend from the Ordovician and Silurian of the Moorfoot and Pentland Hills to the Carboniferous of the central valley, with Glacial Drifts and other superficial deposits, as well as igneous rocks. Arthur's Seat is represented in a somewhat sombre view, but a better one is given with the Burns Monument in the foreground. The views of the romantic glens of Roslin and Hawthornden are good. Of the economic products particular mention is made of the coals and oil-shales, building-stones, bricks, and fire-clays. It is also noted that salt-works on a small scale are still in operation for the preparation of salt rock at Joppa and Pinkie Pans between Portobello and Musselburgh.

Later volumes received, all dated 1912, are West London by Mr. G. F. Bosworth, Oxfordshire by Mr. P. H. Ditchfield, and Breconshire by Mr. Christopher J. Evans. The volume on West London, while full of interesting matter, contains a repetition of the more general parts in the same author's "East London", and the section on geology is the same. The district includes St. Pancras, Holborn, Lambeth, and the area to the west. There are good views of Highgate Ponds and Hampstead, and accounts, with pictures, of some of the Museums. An index completes the work. Oxfordshire contains a well-written section on geology, illustrated by good figures of some fossils and view of Malmstone Quarry at Watlington. The red (ferruginous) lands and iron-ore of Adderbury, Hook Norton, etc., are described, also the Stonesfield Slate, various Oolites, and later deposits. An excellent account of the scenery is given.

Breconshire, so spelt (as we are told) by a decision of the County Council in 1910, is for the most part a mountainous county of Old Red Sandstone with Silurian and Ordovician rocks on the north, and a fringe of Carboniferous rocks with Coal-measures on the south. A somewhat brief account is given of the local geology, with a few geological views and others of river scenery. Agriculture is the main industry, and small fruit is now cultivated in some of the valleys. The physical and geological maps are given as of Brecknock.

VI.—The Students' Handbook of Stratigraphical Geology. Second edition. By A. J. Jukes-Browne, F.R.S. 8vo; pp. xiv, 668. London: Edward Stanford, 1912. Price 12*s.* net (post free 12*s.* 4*d.*).

We welcome a second edition of this comprehensive and well-arranged manual, of which the former edition was noticed in the Geological Magazine for 1902, p. 279. The book has naturally grown in size and in number of illustrations, and it is noteworthy that the author has not introduced any photographic plates. These render some modern works more attractive as picture-books; they are useful in the matter of scenery and rock-structure, but not usually so clear and instructive as regards the stratigraphical arrangement. The author has brought his work well up to date in giving the leading subdivisions of the geological formations in the British Isles, and in various parts of Europe, so that, apart from its essentially British interest, it forms a work of reference on European stratigraphical geology that will be of the greatest service to students and teachers. In the vexatious task of revising the names of fossils according to the latest changes, the author acknowledges the special help of Mr. Henry Woods. We fear, however, that both in palæontological names and in the use of certain chronological terms (such as Valentian, Salopian, and Downtonian) there never will be entire uniformity among geological writers.

The term Charmouthian for part of the Lias (pp. 383, 387) is used for the Middle Lias zones of the Ammonite genera *Paltopleuroceras spinatum* and *Amaltheus margaritatus*, whereas on p. 405 the term is taken to include also the Lower Lias zones of *capricornus* and *armatus*. This is unfortunate and no improvement. As a matter of fact the term is inappropriate as no Middle Lias (as above defined) occurs in the cliffs at Charmouth. If used at all the term should be applied to the Lower Lias clays (zones *obtusus* to *capricornus*). Mr. Jukes-Browne reintroduces his terms of Glevanian, Clavinian, and Vectian, but like new names of fossils they add but a burden to the student who is bound also to learn the older and more widely known names. The Bovey Beds are now placed in the Miocene. The Pleistocene Series is taken to include all deposits (subsequent to Pliocene) "which are older than those containing metal implements of human manufacture". This again is not the usual grouping; the term Holocene is now largely applied to deposits from Neolithic times to the present day, and should at any rate have been so noted.

The extended bibliographical references have been carefully selected, and form an important feature in the volume.

VII.—The Natural History of Clay. By Alfred B. Searle. 8vo; pp. viii, 176. Cambridge: University Press, 1912. Price 1*s.* net.

THIS little work is issued as one of "The Cambridge Manuals of Science and Literature", and will be of most service to those studying the practical uses of clay. As the author remarks, it is difficult to give a definition of clay, especially when it includes such diverse deposits as kaolin, fuller's earth, marl, loam, shale, slate, fire-clay, and boulder-clay. He rightly decides that clay is "not a mineral but a rock", irrespective of any legal significance of the term 'mineral',[1] but ultimately he remarks (p. 150) that "In so far as it can be isolated *true clay* appears to be an amorphous, or practically amorphous, material which may under suitable conditions crystallize into rhombic plates of Kaolinite".

He gives an account of the colours, chemical composition, and physical characters of various clays, but finds fault with the geologists' use of the term 'boulder-clay'. He would like the term "restricted to the plastic portions and not including pockets of sand, gravel, and other non-plastic materials". In practice he would soon find the impossibility of any such restriction. He gives an analysis of boulder-clay, presumably of the clay matrix, but the subject reminds us of a chemist who asked a geologist about an analysis of boulder-clay, and the reply was, "you might as well ask for the analysis of a house." We had not heard of certain Palæozoic or Primary Shales being termed 'marls' when soft and friable, nor are the Thames Valley brickearths as a rule 'natural *marls*'. The geological portions of this work are weak in many respects. The most typical deposits of Kimeridge Clay are not in Huntingdonshire, the 'Kellaway blue clays' are not of freshwater origin, nor are the differences in the Wealden clays "more in the fossils occurring in them than in the characters of the clays themselves", they depend mainly on stratigraphical position.

In another edition the Table of "Chief Clay Rocks (arranged geologically)" should be amplified, as "Oolitic (brick and tile clays)" and "Cretaceous (cement clays, brick clays)" contain no useful information; Oxford Clay, Gault, etc., should be given. Elsewhere in the volume more stratigraphical particulars are recorded, but they are meagre. Watcombe terra-cotta clay should have been mentioned among the Permian clays, and there is some confusion (pp. 54, 131) in the references to Triassic marls, and the Etruria Marl Series in the Upper Coal-measures of North Staffordshire.

VIII.—A Geological Excursion Handbook for the Bristol District. By Sidney H. Reynolds, M.A., F.G.S., Professor of Geology in the University of Bristol. 8vo; pp. 224, with 50 text-illustrations. Bristol, J. W. Arrowsmith, Ltd.; London, Simpkin, Marshall & Co., Ltd. Price 3*s.* 6*d.* net.

WE do not doubt that this little volume will prove a useful and very instructive guide to all interested in the geology of the country around Bristol. The area is naturally limited on the west by

[1] See decision respecting the question "Is China Clay a Mineral?", Geol. Mag., 1908, p. 564.

the Bristol Channel and the Severn as far north as Tites Point, but inland the descriptions take in Frocester near Stroud, and thence southwards they include Bath, Bradford-on-Avon, Westbury, and the country near Frome, together with the Mendip Hills.

In this highly interesting district a great number of geological formations are met with from the Silurian to the Upper Oolites, with sundry igneous rocks, and Post-Tertiary deposits including those of caverns and raised beaches.

The story of the great physical changes indicated by the strata and associated volcanic rocks is briefly and pleasantly told in the Introduction by Professor Lloyd Morgan, whose essay touches on the poetic aspect of geology and is well calculated to stir up enthusiasm.

Then follow the practical instructions on excursions, aided by useful diagram-sections and maps, all indicative of the author's wide and exceptional knowledge of petrography, stratigraphy, and palæontology.

Of late years special attention has been given to the Carboniferous Limestone, as well as to the volcanic rocks of Mendip and of the coast near Weston-super-Mare. The particulars given of the zonal divisions in the Carboniferous will be appreciated, but for the sake of the younger students it would have been well to indicate the classes of organisms to which belong such forms as *Caninia*, *Seminula*, *Syringothyris*, etc. The presence of arborescent markings in the Carboniferous Limestone is interesting; the author refers to them as 'Cotham Marble' bands, but here the use of the term Landscape Marble would have been better. Cotham Marble has its own horizon in the Rhætic Beds, and if there had been good local sections at Cotham the author would no doubt have guided us to them. He wisely, however, gives no account of temporary exposures. The famous section at Aust gives the best section of the strata. The Lias and Inferior Oolite also are seen in various noted localities, and those who are interested in *hemeræ* will find an enumeration of thirty-one for their guidance. They are, however, for the specialist, and the student will find the ordinary groupings duly indicated. The names Upper and Lower Lias might have been introduced on the Table II.

IX.—Brief Notices.

1. Geological Map of Central Europe.—A small colour-printed map of this region, on the scale of 100 miles to 1 inch, has been published by Mr. Stanford (1911), price 5*s*. It shows the leading geological systems and intrusive igneous rocks, under twelve tablets: Miocene and Pliocene, Eocene and Oligocene, Carboniferous and Permian, Upper Silurian and Devonian, being respectively grouped together. Certain pre-Cambrian or Archæan rocks are classed as 'Brioverian', which seems too local a term for such a map, while another tablet indicates "Crystalline schists and gneiss". The topography is clear, showing the rivers, mountains, and principal towns, but no railways, and the colours for the most part are distinctive, although here and there, in the smaller areas, numbers printed on map and tablets would have been an advantage. The map includes Dublin, Hull, and Kiel on the north, Warsaw and Belgrade on the east, Brindisi, northern

Sardinia, and Madrid on the south. It will therefore prove a very handy guide to the geological traveller, and be useful also for general reference.

2. Mineralogy. By F. H. Hatch, Ph.D., etc. Fourth edition, entirely rewritten and enlarged. pp. ix + 253, with 124 illustrations. London: Whittaker & Co., 1912. Price 4*s*. net.

After passing through three editions without change this little manual has been entirely rewritten, and in its latest form is twice its original bulk. In the first part, dealing with the properties of minerals, the chapter on physical properties has been considerably enlarged, and a good account of the phenomenon of refraction is included. The use of a different notation for elasticity axes might have been preferred, however; confusion with the crystallographic axes may arise through the employment of small Old English characters of the same notation. It may be noted also that "statical changes", mentioned in connexion with pyro-electricity (p. 57), should evidently be read as "statical charges". A list of the more important mineral species, classified according to chemical composition, makes a useful addition.

A much fuller account of the rock-forming minerals is to be found in the second or descriptive portion, and the chapter on ores is almost three times its original size. Considerable attention seems to have been paid to the preparation of this book, and the student of elementary mineralogy would do well to provide himself with a copy.

3. *Belemnitella mucronata* Chalk of Simbirsk.—The geological library of the British Museum has received from the Ghornoi Institute of St. Petersburg a copy of the rare volume "Nauchno-istorich. Sbornik. — 1873", which contains Laghusen's paper on the *B. mucronata* chalk of Simbirsk, with its four beautiful plates. One might easily fancy oneself dealing with a typical Norwich fauna. Considering the Ghornoi Institute had but three copies of the work left, their action in presenting one to the British Museum (Nat. Hist.) is most generous. It is of much service and will be highly appreciated.

4. Topographic Map of Meekatharra, Western Australia.—This map, on the scale of 40 chains to an inch, and published by the Geological Survey of Western Australia, is the work of Mr. H. W. B. Talbot, Assistant Field Geologist, and represents part of the Murchison Goldfield.

REPORTS AND PROCEEDINGS.

I.—Geological Society of London.

February 28, 1912.—Dr. Aubrey Strahan, F.R.S., President, in the Chair.

The following communications were read:—

1. "Late Glacial and Post-Glacial Changes in the Lower Dee Valley."[1] By Leonard Johnston Wills, M.A., F.G.S., Fellow of King's College, Cambridge.

[1] Communicated by permission of the Director of H.M. Geological Survey.

After pointing out that the district where the River Dee leaves its deep valley in the Welsh hills and enters the lower ground occupied by the Coal-measures is a critical one in connexion with its post-Glacial history, the author briefly describes the composition and local distribution of the Irish Sea and Welsh Drifts.

The second part of the paper deals with post-Glacial changes in the topography of the Dee Valley. The term 'post-Glacial' is here applied to events that occurred after the period of maximum glaciation. Many of the changes dealt with may have originated in late Glacial times.

In the Llangollen district the modifications are dependent on the serpentine course of the whole valley. Glacial phenomena have led to the cutting of overflow channels across the necks of the loops, at great heights above the river. Two of these have become permanent courses of the Dee, with the result that deep gorges have been formed across the rocks while the deserted loops have been left like gigantic oxbows.

The other diversions appear to be due to the fact that the post-Glacial course of the river was determined by the surface configuration of the Drift, and has since been excavated into the solid rock at places where it never flowed before. They are, in fact, cases of superimposed drainage.

An unimportant diversion at Argoed (near Trevor) is described, in which the river takes a longer course than in pre-Glacial times. The most notable change, however, occurs near Cefn, and involves the cutting of an entirely new course, some ten miles long, between that locality and Eyton near Overton. Details of this gorge are given, and a suggestion is put forward to explain why the river took this course.

The general direction of this, the present, Dee valley is easterly. The pre-Glacial course has been traced southwards with some precision from near Cefn to Chirk, and then with less certainty in a more south-easterly direction for a few miles. In that direction the Drift is so thick that it has been found impossible to trace the former course until it rejoins the deep buried valley which Dr. Strahan discovered in the neighbourhood of Chester. The author's observations have proved the continuation of this buried valley southwards nearly to Bangor-on-Dee. Near here, at Roden's Hall, the rock-surface is 30 feet below sea-level.

The southerly bend of the pre-Glacial valley near Cefn to Chirk, and then towards Whittington, suggests the possibility of a confluence of the Severn and the Dee, and this is shortly discussed.

It is shown that formerly the River Ceiriog joined the pre-Glacial Dee at Chirk, and that its present course below Chirk is post-Glacial. The gravels of this valley suggest that the post-Glacial drainage always followed this course. It is shown, however, that the Morlas Brook, which is now a tributary of the Ceiriog, was not always so, its early post-Glacial course having been to the Severn.

The slope of the pre-Glacial valley-floor and the uplift which is indicated by the buried valley, now many feet below sea-level, are briefly discussed.

2. "The Glen Orchy Anticline (Argyllshire)." By Edward Battersby Bailey, B.A., F.G.S., and Murray McGregor, M.A., B.Sc.

The district described stretches from the head of Loch Awe to Beinn Achallader, and is the south-eastern continuation of the Fort William, Ballachulish, and Appin country dealt with by one of the authors two years ago. The subject is the tectonics of the schists.

In the centre of the district a diagrammatic recumbent fold, of at least two miles in magnitude, is exposed to view in Beinn Udlaidh, in the heart of a gentle anticline, to which the name of the Glen Orchy Anticline is fittingly assigned. Around the western, southern, and eastern rim of this anticline, are found rocks which lie upon a structurally higher level than the Beinn Udlaidh Fold. A limestone which occurs among these rocks is correlated with the Ballachulish Limestone, and is believed to mark the core of the great recumbent Ballachulish Fold, everywhere in this district underlain by the Ballachulish Slide (fold-fault). Incidentally this interpretation involves a displacement of at least twenty-four miles along the Ballachulish Slide. Finally, an important inversion of the Ballachulish Limestone and Slide is discussed in connexion with a description of the Beinn Doirean and Beinn Achallader range of mountains on the east side of the Glen Orchy Anticline.

March 13, 1912.—Dr. Aubrey Strahan, F.R.S., President, in the Chair.

The following communications were read:—

1. "On the Glacial Origin of the Clay-with-Flints of Buckinghamshire, and on a Former Course of the Thames." By Robert Lionel Sherlock, D.Sc., A.R.C.S., F.G.S., and Arthur Henry Noble, B.A., F.G.S.

The paper is founded on observations made during the mapping of some 260 square miles on the 6 inch scale, in Buckinghamshire, Berkshire, Hertfordshire, and Middlesex.

The superficial deposits are divided into Clay-with-Flints with the associated Gravelly Drift and the Fluvio-glacial Gravels. There are, in addition, certain high-level gravels, older than any of these, and also the river gravels and alluvium of the present streams, none of which deposits are dealt with in the paper.

Evidence is given to show that the Clay-with-Flints and Gravelly Drift were formed by an ice-sheet which came from the north or north-west over the Chiltern Hills. Only the clean upper layers of ice surmounted the escarpment, and this produced the Clay-with-Flints and Gravelly Drift from the 'head' (Chalk and Eocene waste), which had been accumulating for ages.

At that time the Thames flowed, at the foot of the Eocene escarpment, from Bourne End through Beaconsfield and Rickmansworth to Watford. The ice-sheet blocked the river-channel between Bourne End and Rickmansworth about the time of maximum cold, and diverted the Thames southwards at Bourne End. The river beyond Watford was further blocked by the Eastern Drift, which has left

Boulder-clay near Hatfield and at Finchley. The section of the river between Rickmansworth and the Eastern Drift had its direction of drainage reversed, and the water escaped at Rickmansworth by a new channel which became the Colne.

On the melting of the ice, Fluvio-glacial Gravels (Plateau Gravels of some writers) were left over a great area. These gravels are composed chiefly of Eocene and Cretaceous materials derived from the Gravelly Drift, but also contain Bunter pebbles which have been brought down the Thames. The Bunter pebbles are particularly abundant in a band between Bourne End and Watford; to the south only a few, presumably washed out of the band, are found. They are believed to show that the Thames in times of flood returned to its former course.

The floods from the melting ice, added to the waters of the Thames and Colne, produced, by denudation of the Eocene clays, the great flat through which the Thames now flows, east of Maidenhead, and which, opposite Iver, is 8 miles wide.

After the retreat of the ice, the Wye and Misbourne extended their channels over the Fluvio-glacial Gravel flat, and some other small streams were formed.

2. "Some New Lower Carboniferous Gasteropoda." By Mrs. Jane Longstaff (*née* Donald), F.L.S. (Communicated by Dr. G. B. Longstaff, M.A., F.G.S.)

Eight species of Gasteropoda are described, six being regarded as belonging to five new genera or sub-genera, the others representing *Pithodea*, De Koninck, which has not previously been recorded from the British or Irish Carboniferous Limestone. Among others, the shell of *Pleurotomaria* (*Tropidostropha*) *Griffithi*, M'Coy, is described in detail, and the nature of the fine pitting of its external surface is discussed.

II.—Mineralogical Society.

March 12, 1912.—Professor W. J. Lewis, F.R.S., President, in the Chair.

Dr. G. F. Herbert Smith and F. N. A. Fleischmann: On the Zeolites from Killyflugh and White Head, County Antrim. Chabazite occurs in three different kinds of crystals and gmelinite in two, and the former is also found pseudomorphous after calcite. Analcite occurs in clear trapezohedra, and natrolite in fine needles. The character of the occurrences was described.—Dr. J. Drugman: On Quartz Twins. Further specimens of bipyramids twinned on the primary rhombohedron from the Esterel, France, were shown, thus establishing this mode of twinning, which was first described by Q. Sella in 1858. From the same localities were shown also bipyramids twinned on ξ $(11\bar{2}2)$, in which, too, the prism is absent and there is no flattening perpendicular to the twinning plane as in the Dauphiné and Japanese specimens.—T. V. Barker: Note on the Optical Properties of Mercuric Iodide. Preliminary determinations by means of two 30° prisms gave 2·746 and 2·447 as the values of the ordinary and extraordinary refractive indices sodium, and 2·566 and

2·357 for lithium light, the degree of accuracy being about 0·002. More accurate values are anticipated when better prisms have been prepared, but the results so far obtained suffice to show that the double refraction and colour dispersion are remarkably large in amount.—Arthur Russell: Notes on the Minerals and Mineral Localities of Shropshire. The occurrences of thirty-two species, excluding rock-forming minerals, were described. Calcite was obtained at Snailbeach Mine, Minsterley, in splendid crystals of varied habit, among others being large, pale mauve, rhombohedra twinned on *e* (111), and opaque, white, prismatic crystals twinned on *r* (100). Very large crystals of barytes and fine crystals of calcite came from Wotherton Mine, Chirbury. The occurrence of pyromorphite and witherite at several localities was noted.—Dr. Emil Hatschek exhibited a series of specimens and lantern slides illustrative of some reactions in gels. An inorganic gel (silicic acid) was used, and the compounds resulting from the diffusion in it of several solutions were shown; there is a tendency to banding in the upper part of the precipitate, while spherulitic growths were obtained in nearly every case. Mr. W. Campbell Smith exhibited a spherulitic dolerite from Vryheid, Natal; the rock was interesting on account of the size and beauty of the spherulites, which were revealed on weathered surfaces.

III.—Zoological Society of London.

March 19, 1912.—S. F. Harmer, Esq., M.A., Sc.D., F.R.S., Vice-President, in the Chair.

Mr. T. H. Withers, F.G.S., read a paper, communicated by Dr. W. T. Calman, F.Z.S., on "Some early Fossil Cirripedes of the genus *Scalpellum*".

Attention was drawn to the form of the carina of the geologically older species of *Scalpellum*, and it was shown that the earliest forms known resembled more closely the carina of *Pollicipes*, from which *Scalpellum* is considered to be derived. An almost complete capitulum of the Albian *Scalpellum arcuatum* was described, together with some scales of the peduncle, and a restoration was given. This specimen was important because, with the exception of a few detached valves found in the Aptian (Lower Greensand), it was the oldest known fossil Cirripede that could with certainty be referred to the genus *Scalpellum*, *sensu lato*. *S. arcuatum* was considered to be an ancestral form of the group of almost exclusively deep-sea species, which Dr. P. P. C. Hoek had separated as a sub-genus under the name *Arcoscalpellum*, and its relationship to other species was discussed. *S. trilineatum* was also redescribed.

CORRESPONDENCE.

A HUMAN SKELETON IN GLACIAL DEPOSITS NEAR IPSWICH.

Sir,—My attention has been drawn to two communications[1] in the April Number of your Magazine dealing with the human skeleton I discovered here in October of last year.

[1] See Geol. Mag., April, 1912, pp. 164 and 187.